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Sugiura et al.

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(45) **Date of Patent: Aug. 25, 2009**

(54) **VALVE TIMING CONTROLLER**

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(73) Assignee: **DENSO CORPORATION**, Kariya (JP)

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F01L 1/34 (2006.01)

(52) **U.S. Cl.** **123/90.15**; 123/90.17; 464/160; 475/338

(58) **Field of Classification Search** 123/90.15, 123/90.16, 90.17, 90.18; 464/1, 2, 160; 475/331, 475/338, 341
See application file for complete search history.

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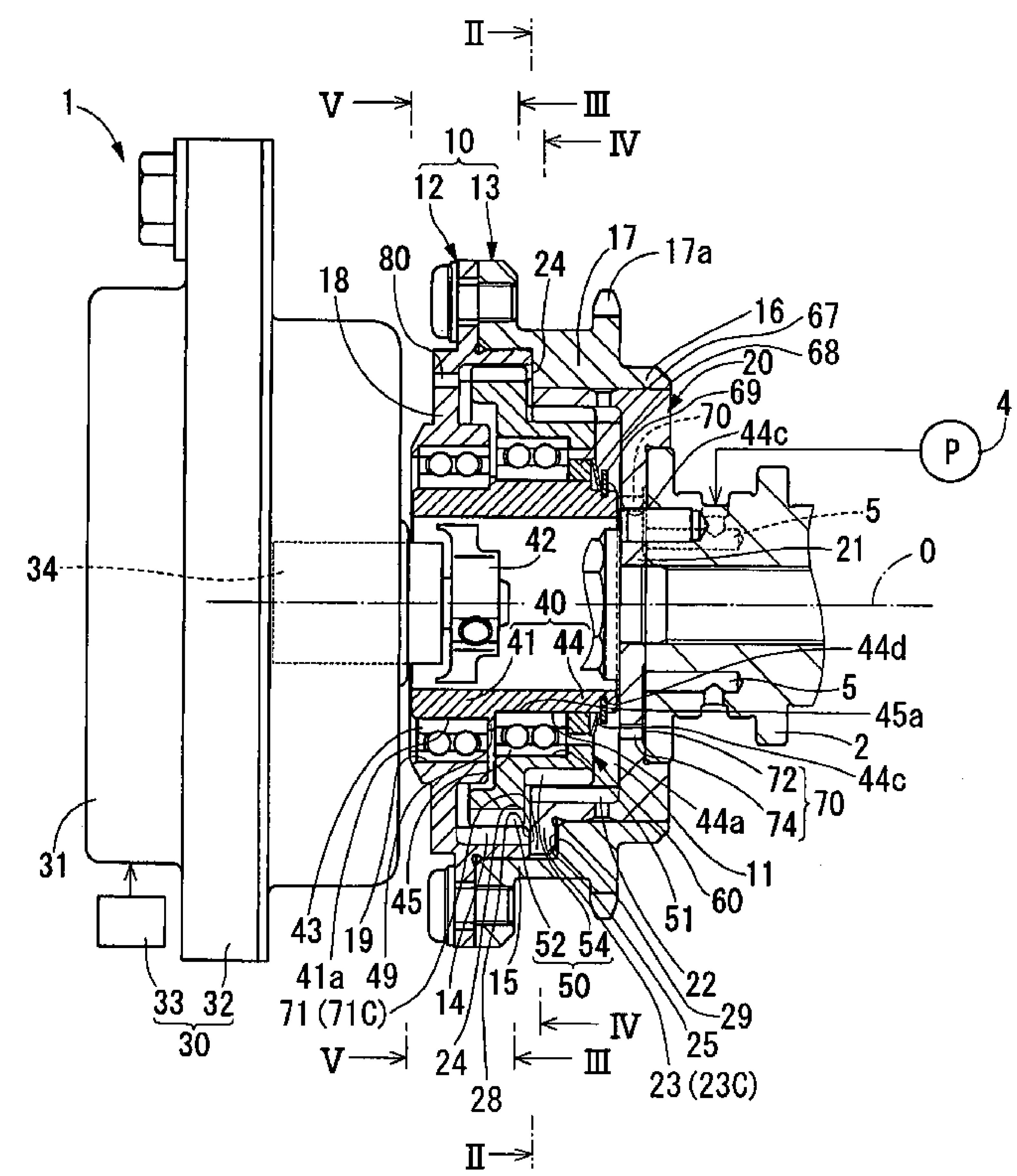
(57) **ABSTRACT**

A valve timing controller is provided with a first rotary element including a first gear part, a second rotary element including a second gear part, and a third rotary element including a third gear part and a fourth gear part. The third gear part and the fourth gear part are meshed respectively with the first gear part and the second gear part. A stopper is provided so as to extend in the first rotary element in the radial direction for regulating a relative rotational phase shift angle between the first rotary element and the second rotary element. An interposing assembler is provided on the second rotary element for rotatably interposing the stoppers in an axial direction.

19 Claims, 14 Drawing Sheets



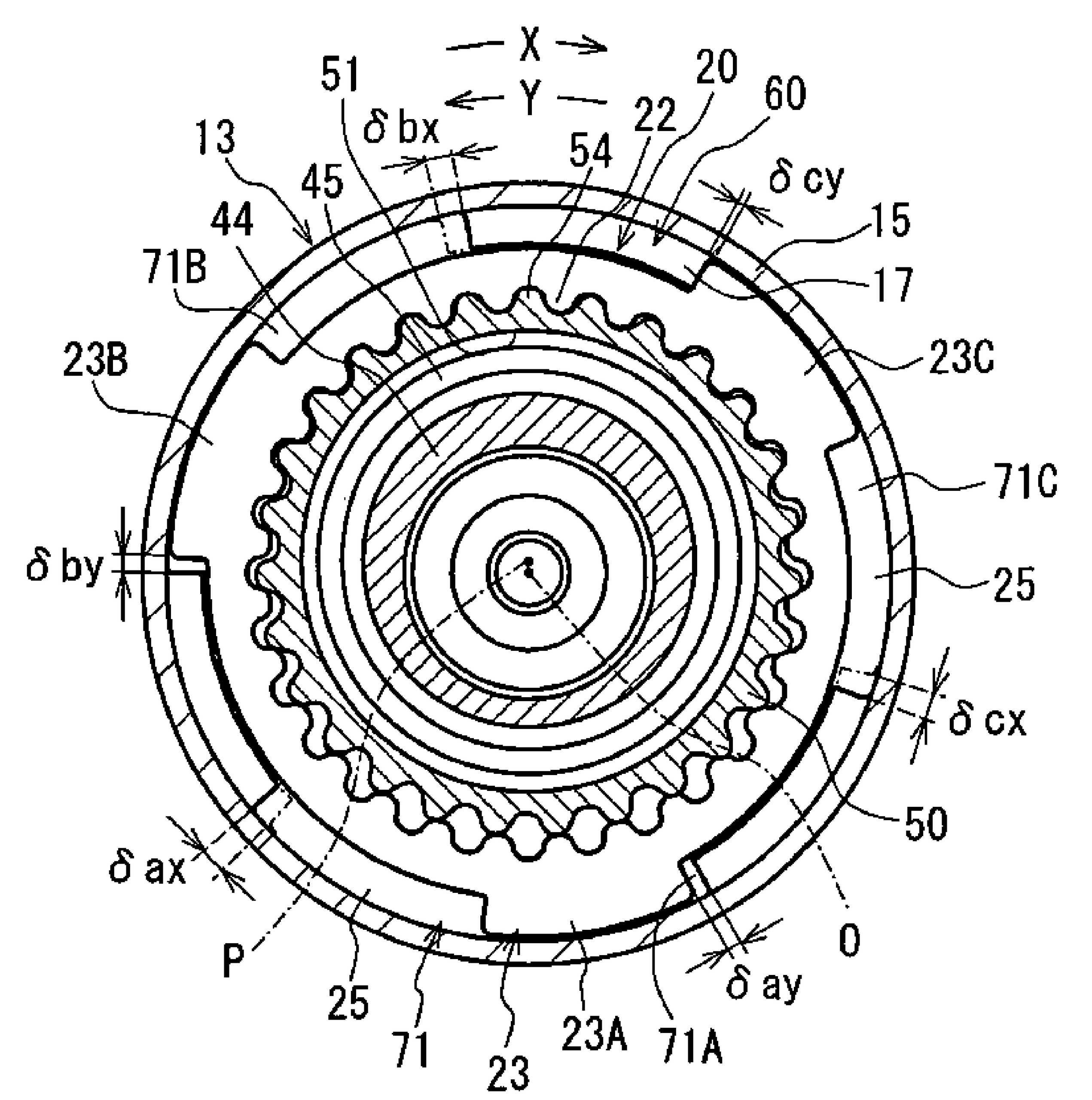
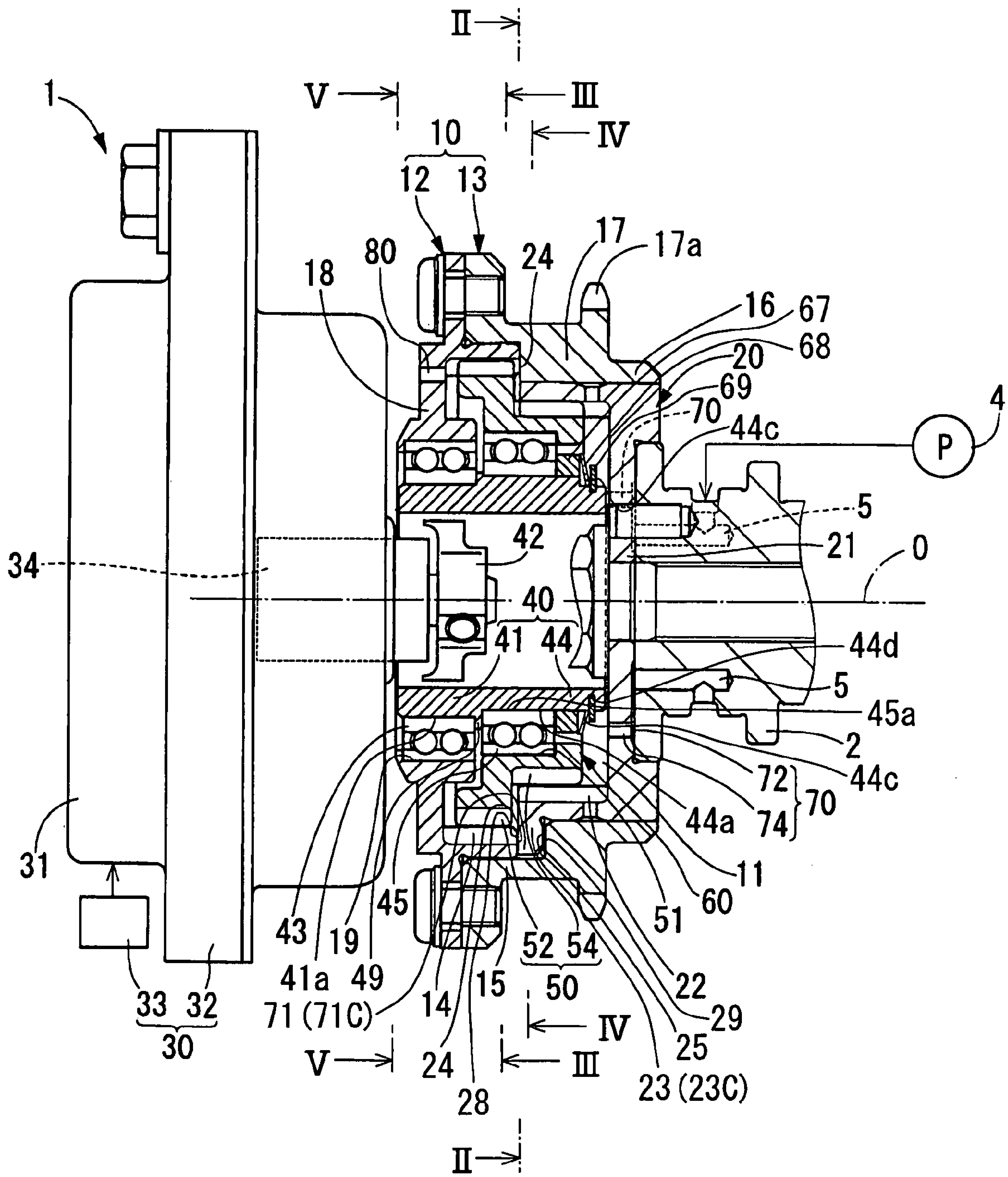


FIG. 1



1
II
III
IV
V
10
12
13
17
17a
16
67
68
20
69
70
44c
4
P
5
21
0
42
40
41
44
44d
45a
2
72
74
44a
11
60
51
22
29
25
23 (23C)
28
24
14
15
52
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71 (71C)
41a
49
43
19
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80
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31
33
32
30

FIG. 2

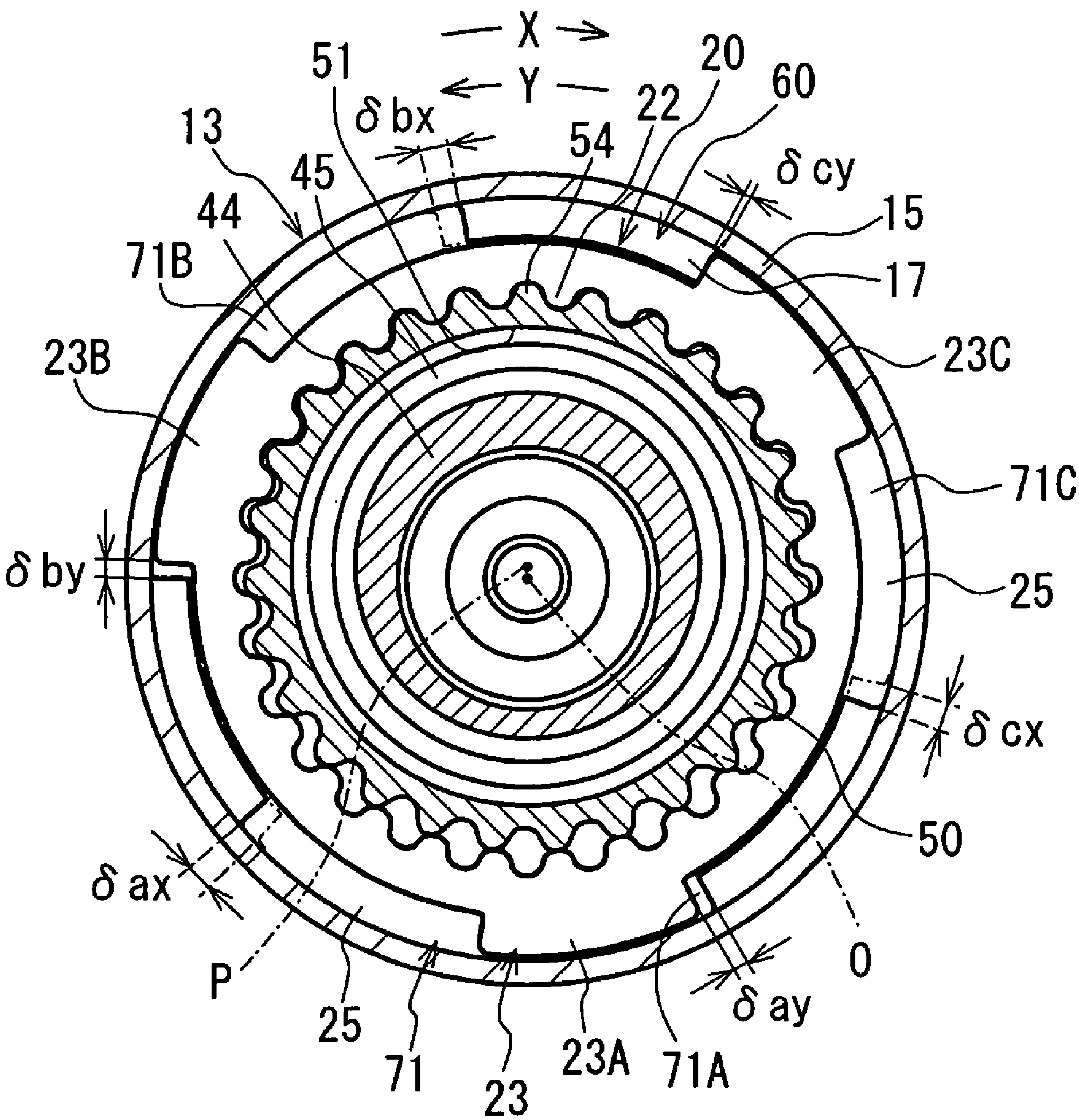
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FIG. 3

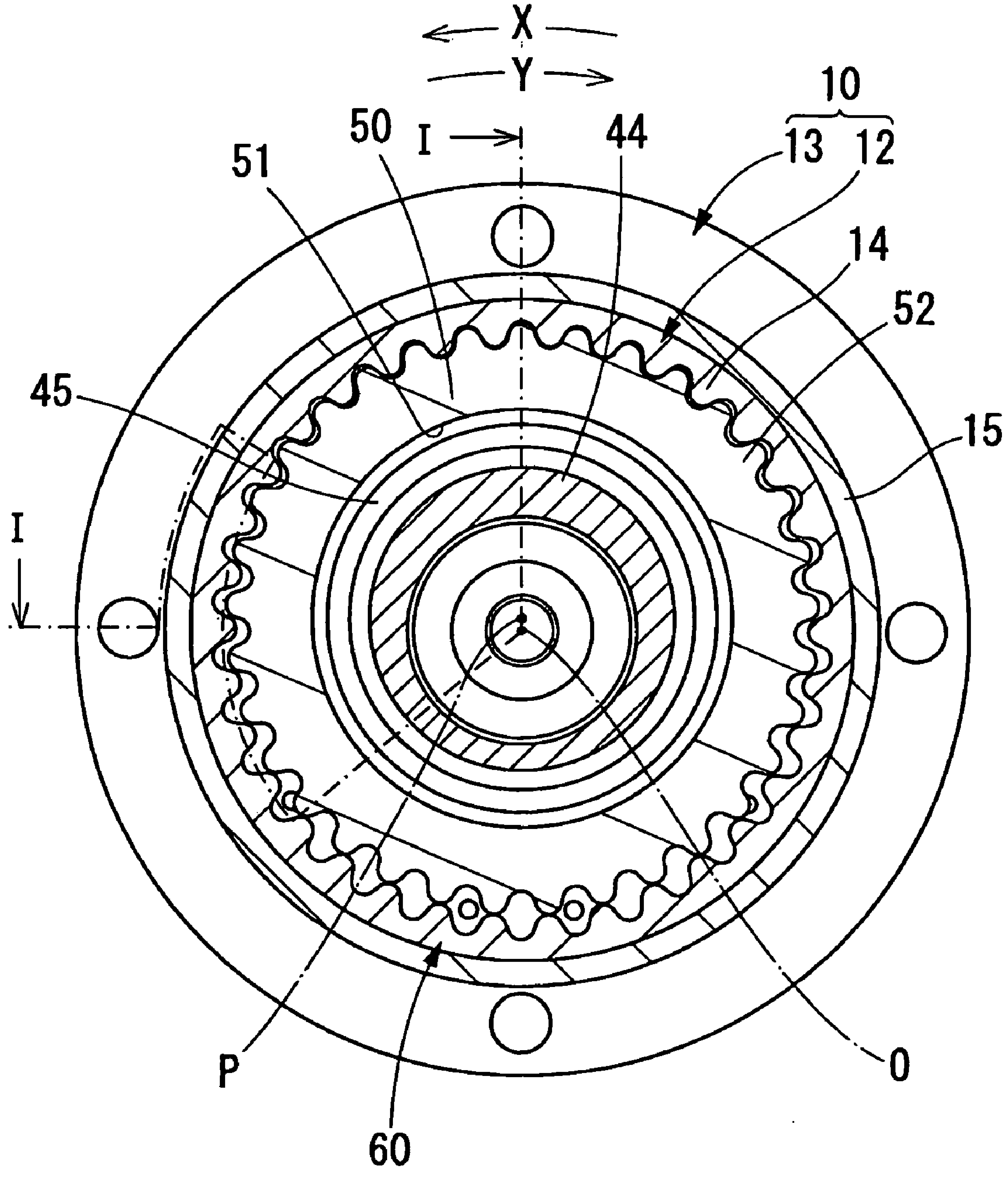

FIG. 4

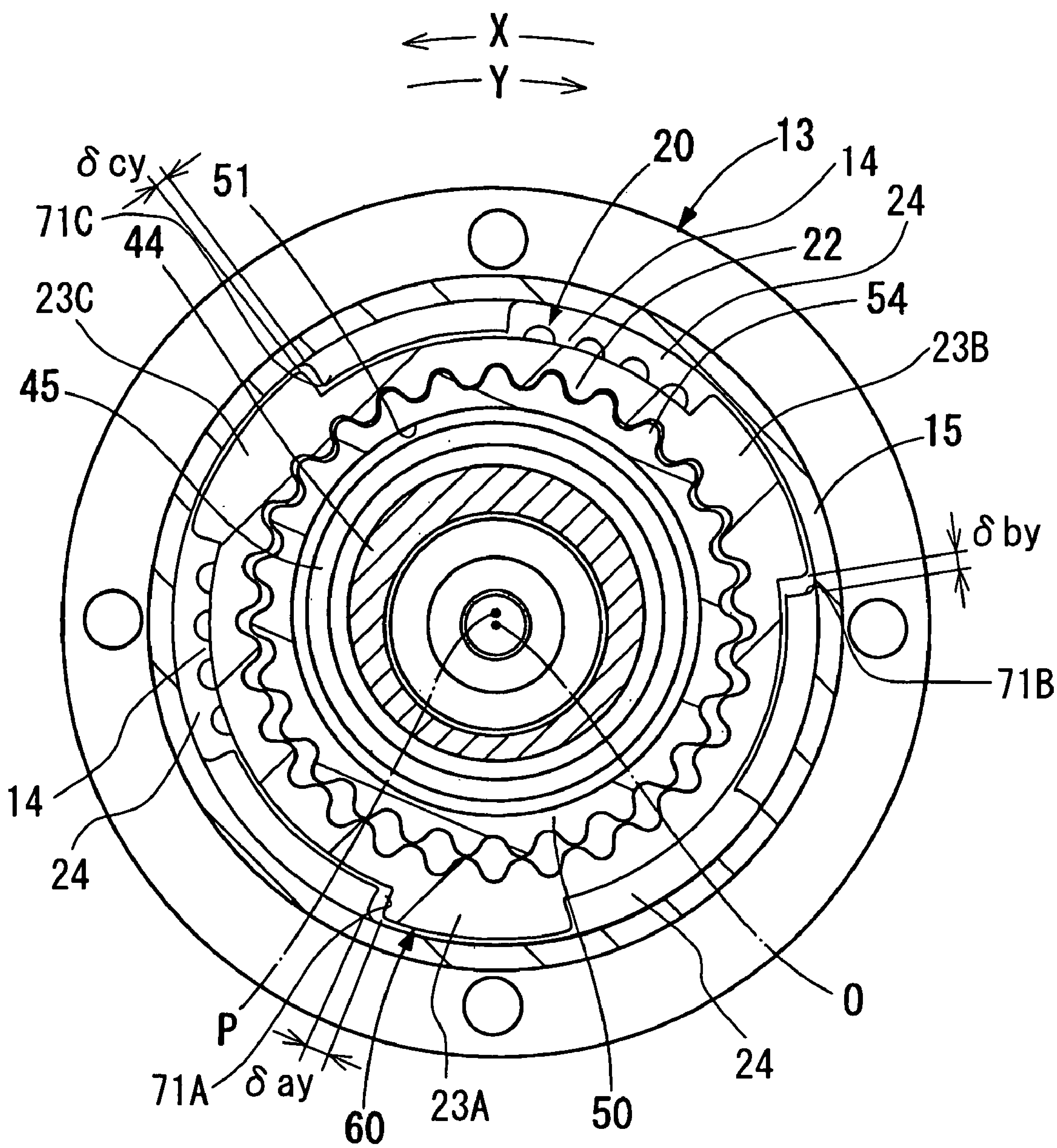
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FIG. 5

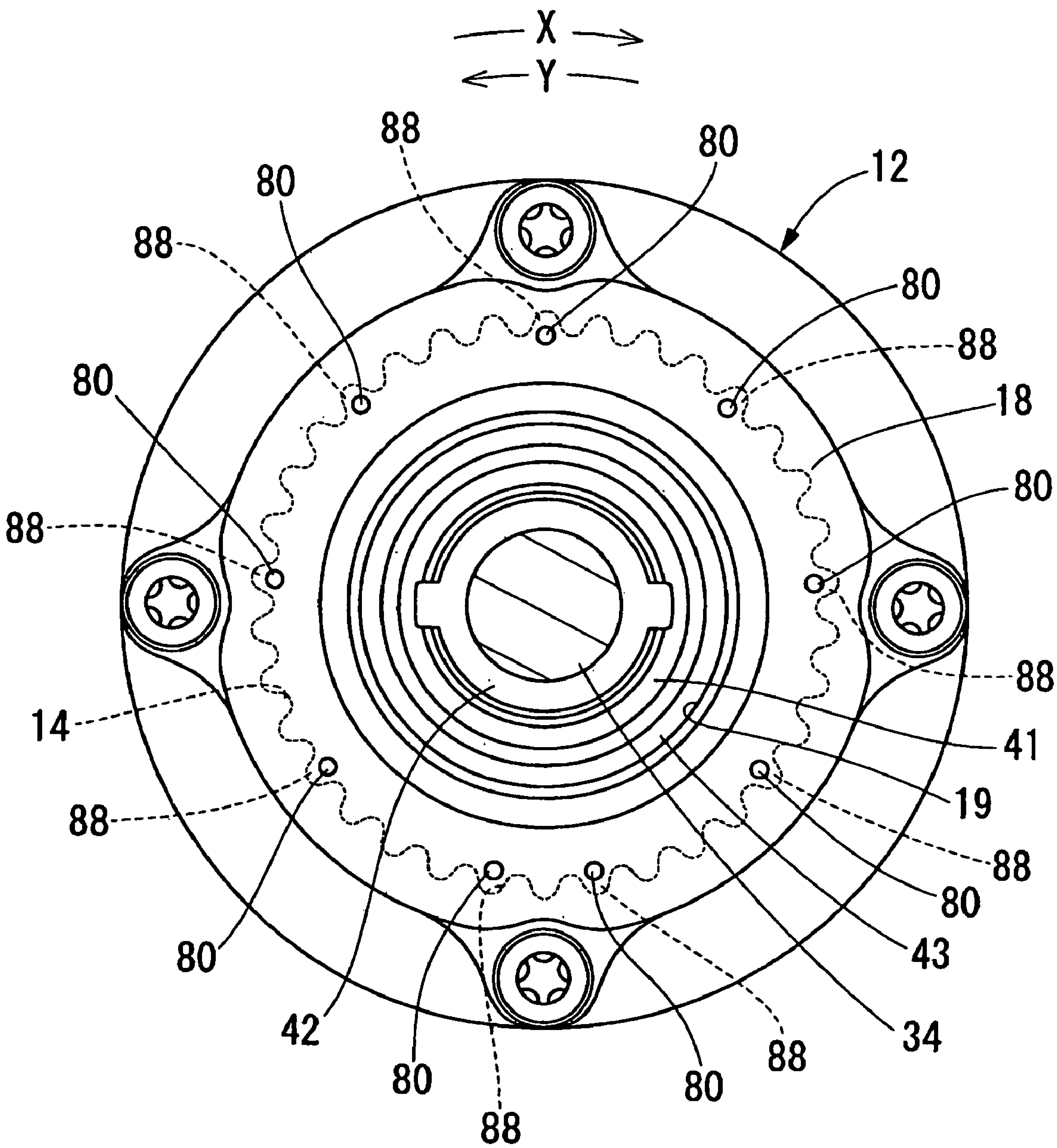
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FIG. 6

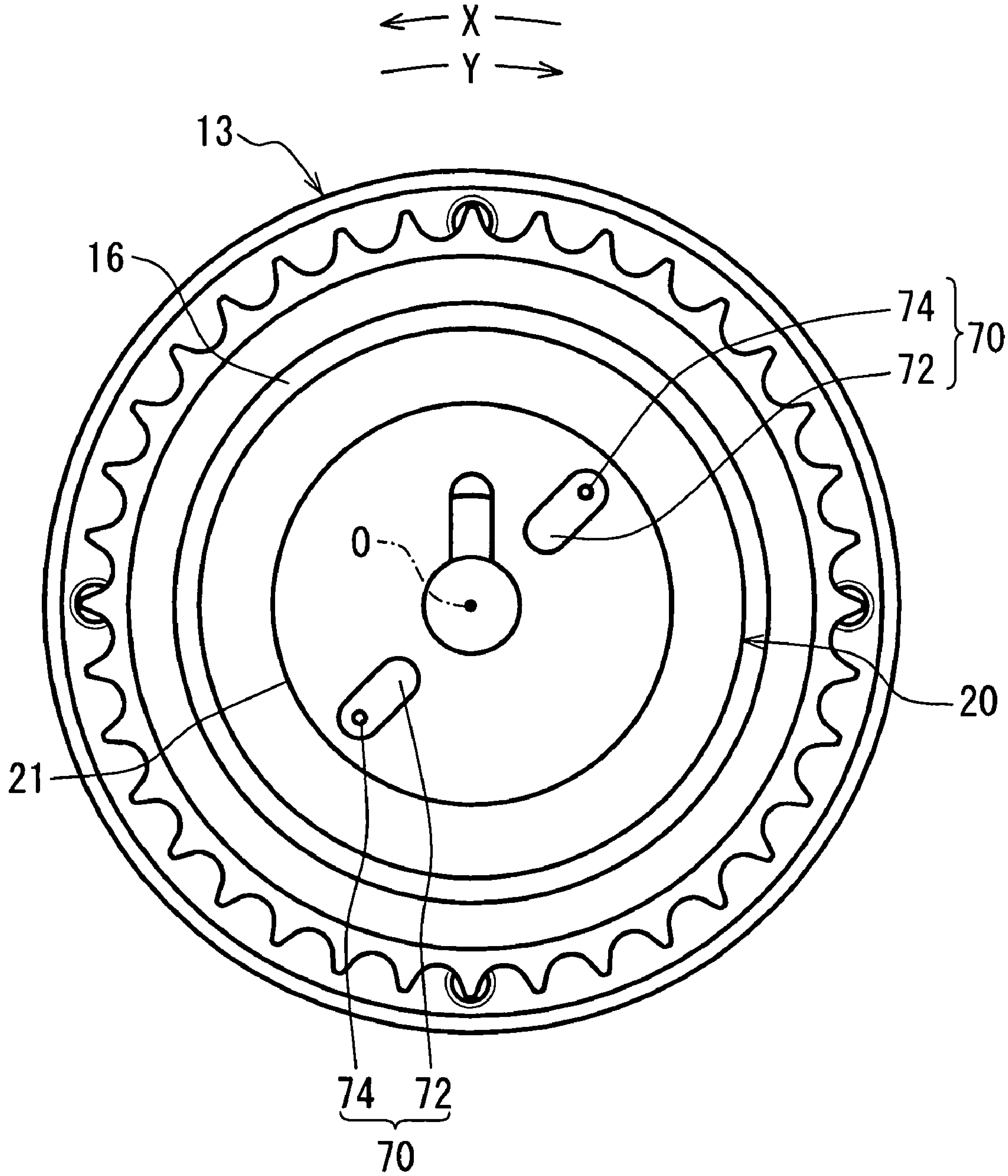


FIG. 7

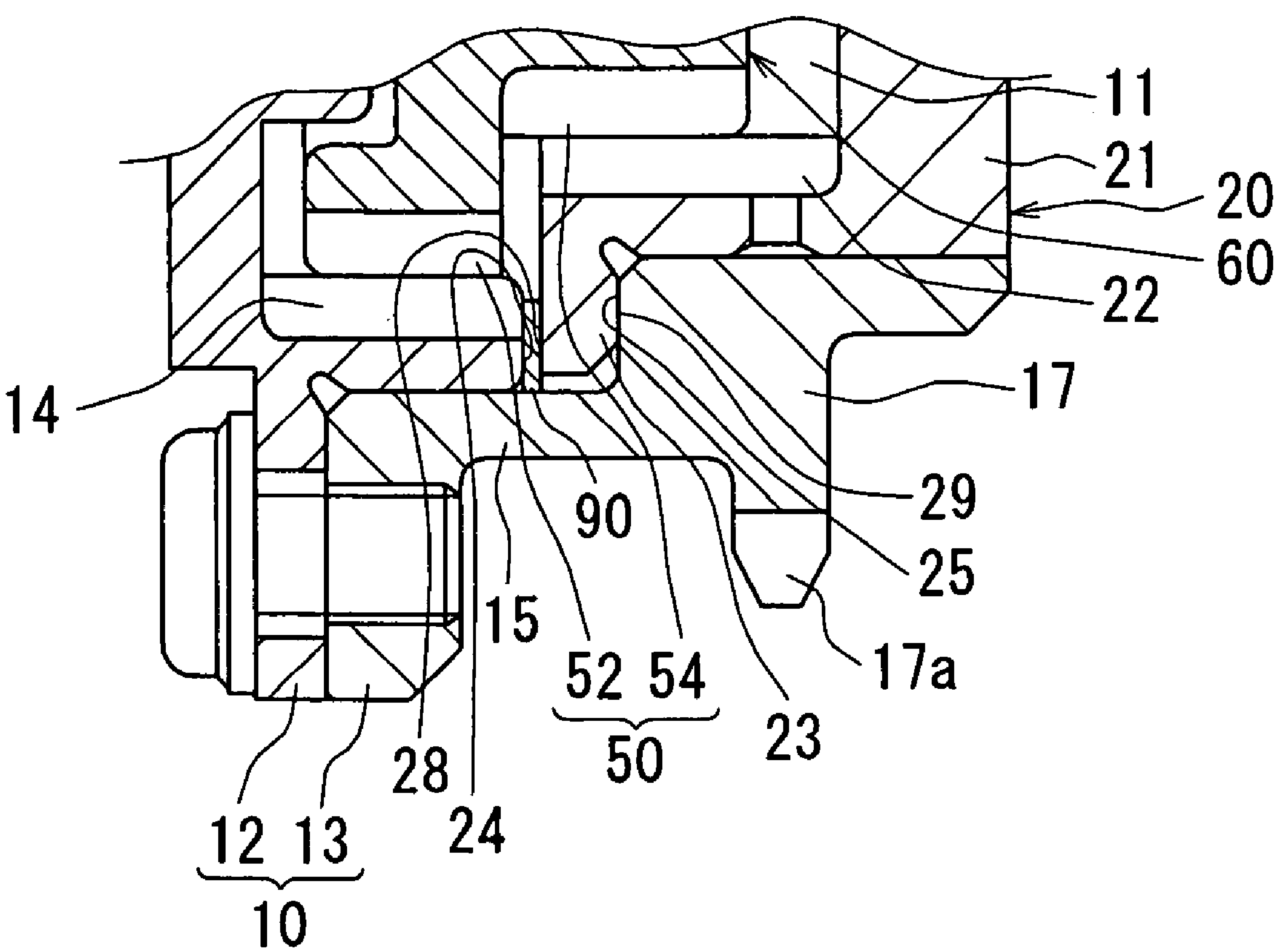
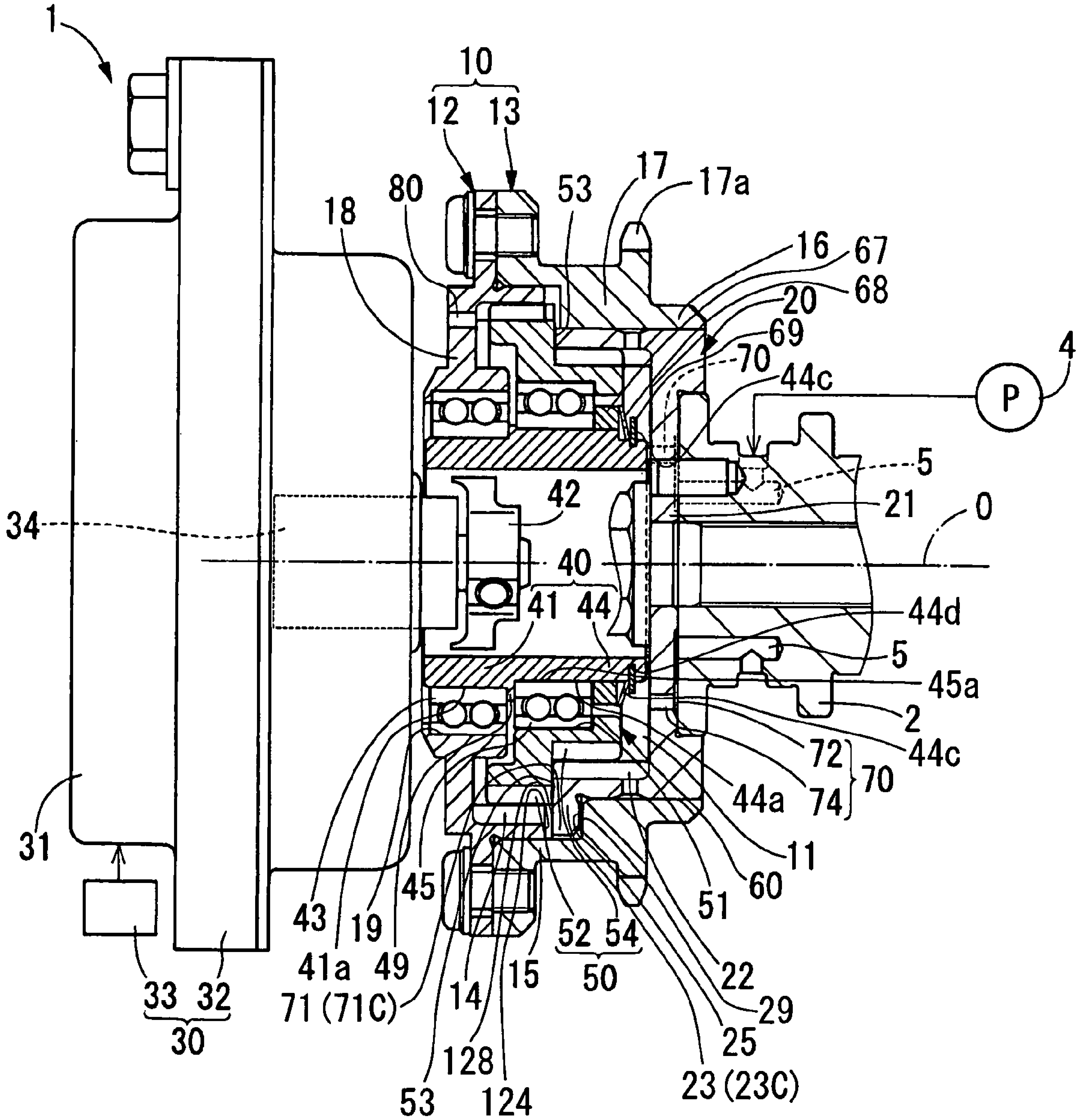


FIG. 8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17a
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67
20
68
69
70
44c
P
4
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42
21
0
34
40
41
44
44d
5
45a
2
72
44c
70
74
44a
11
60
51
31
43
19
45
41a
49
71 (71C)
14
15
52
54
50
22
29
25
23 (23C)
128
124
53
33
32
30

FIG. 9

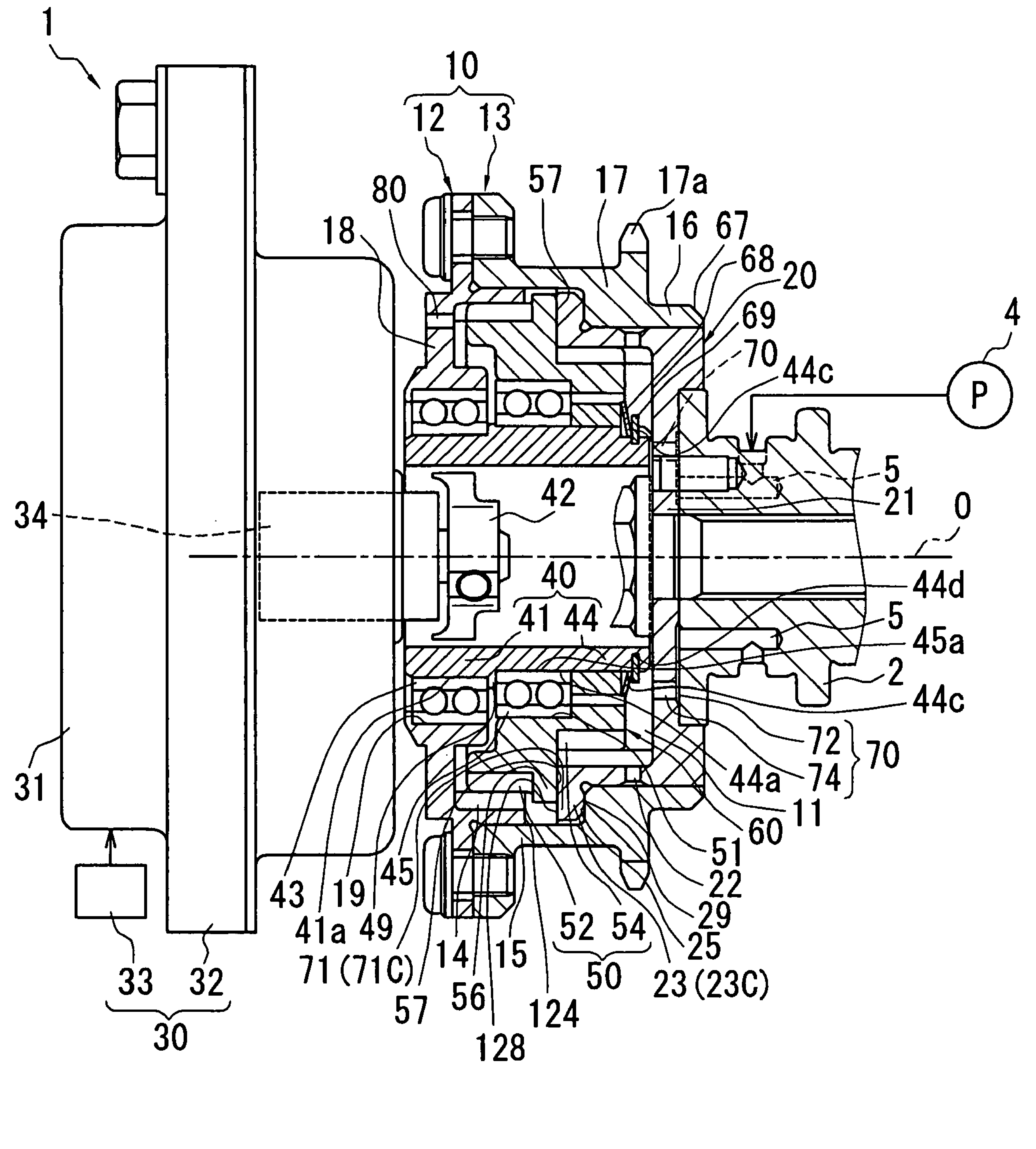
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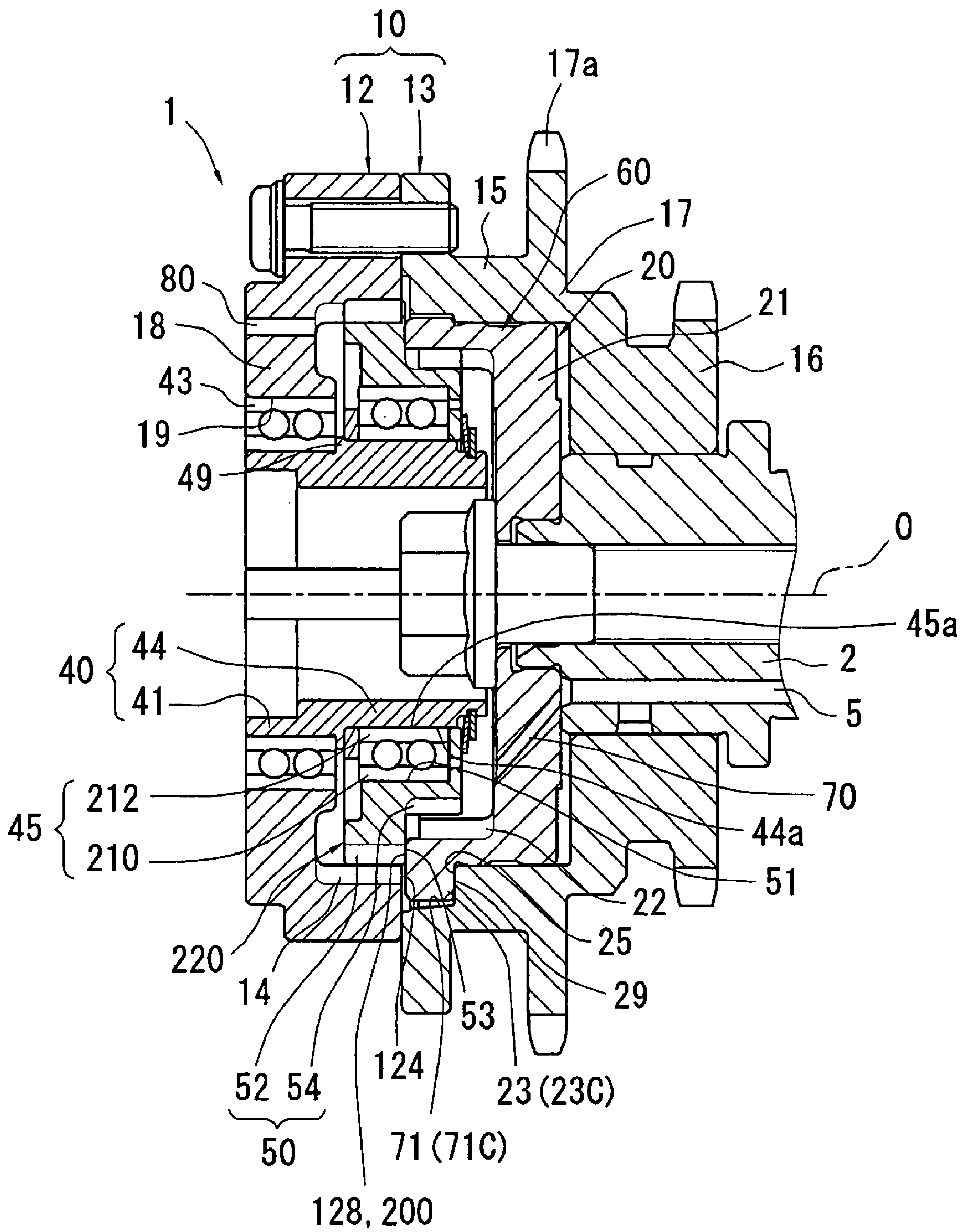
FIG. 10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212
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44a
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124
23 (23C)
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128, 200

FIG. 11

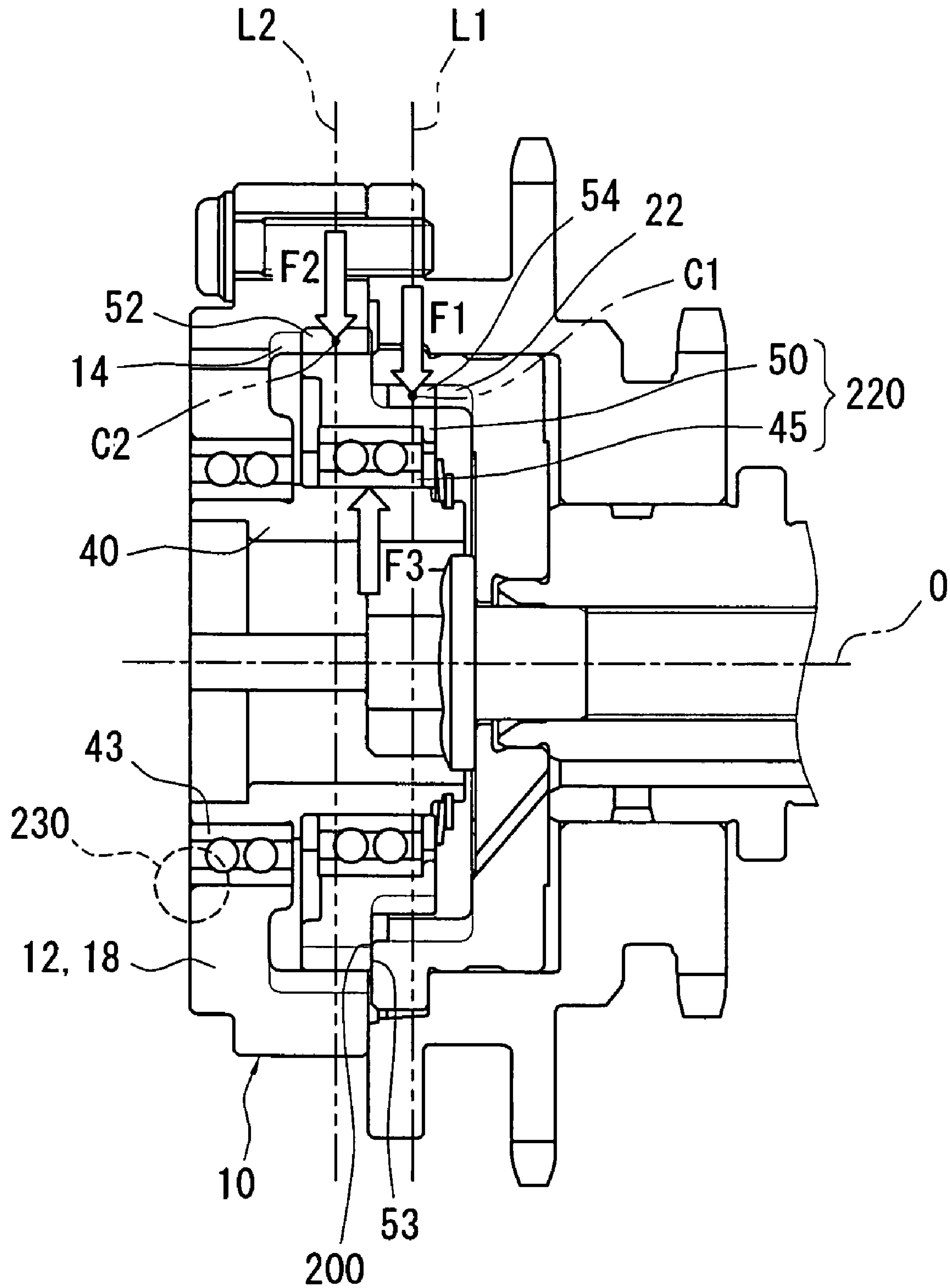

FIG. 12

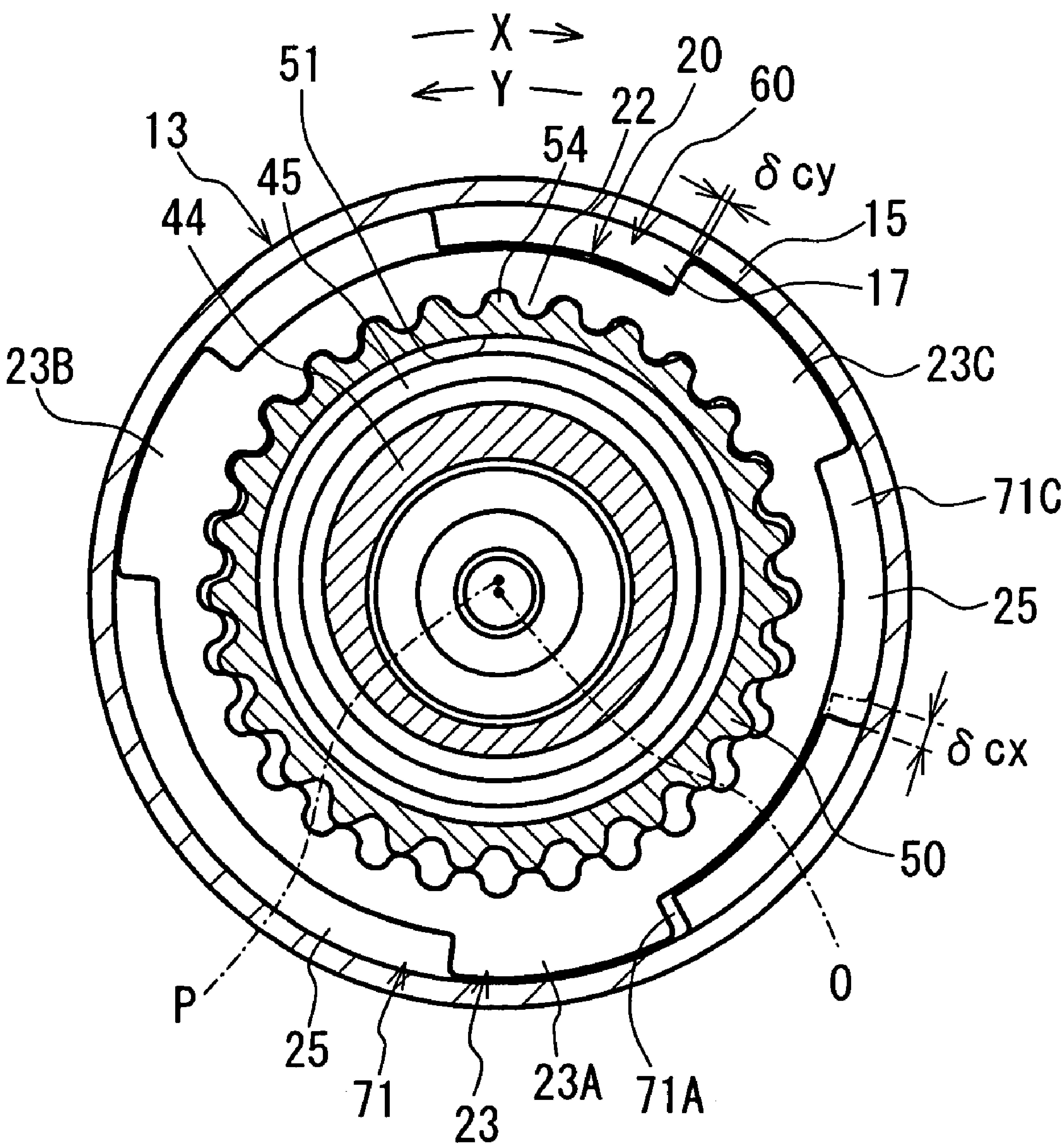
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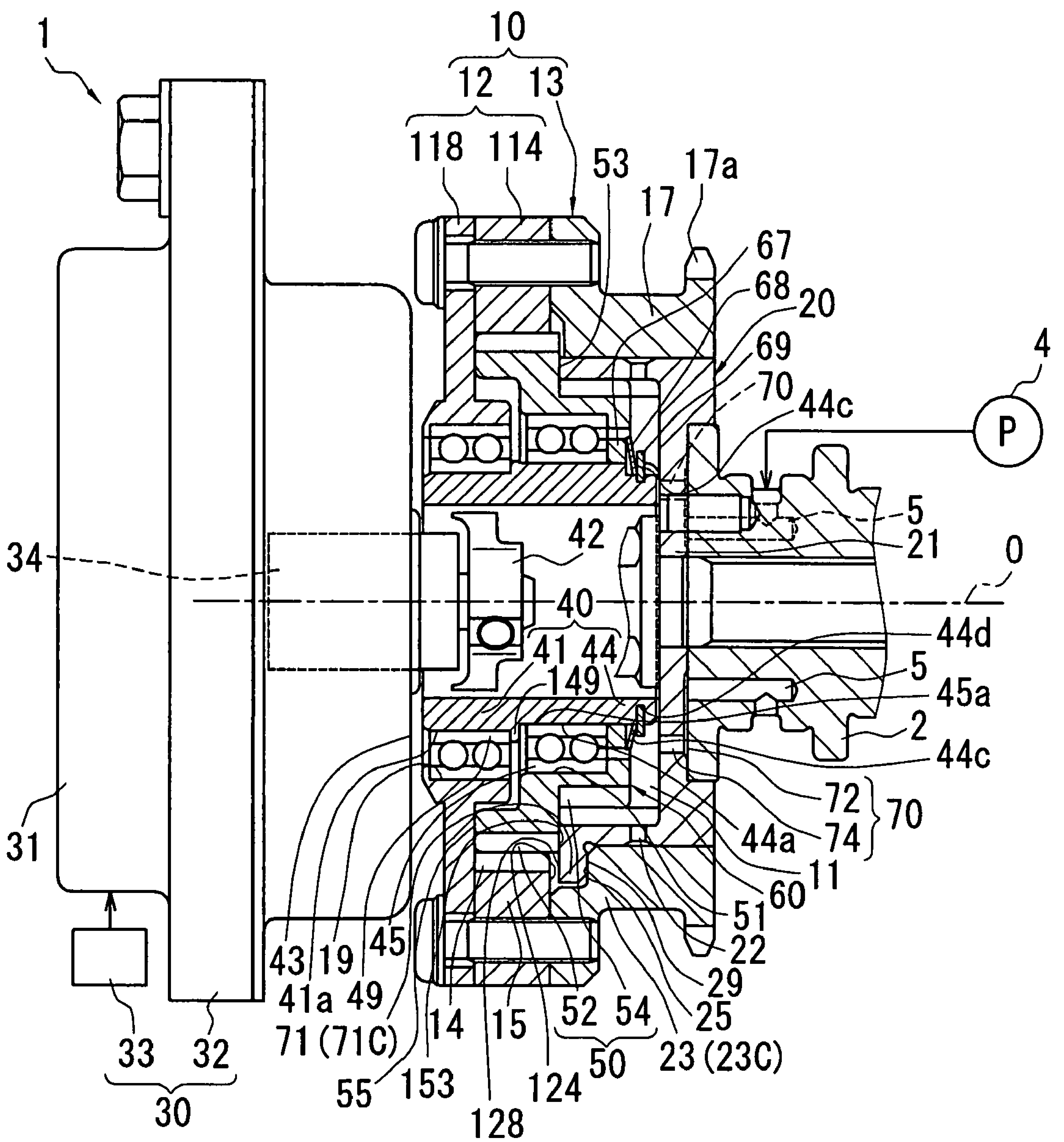
FIG. 13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149
44d
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44c
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74
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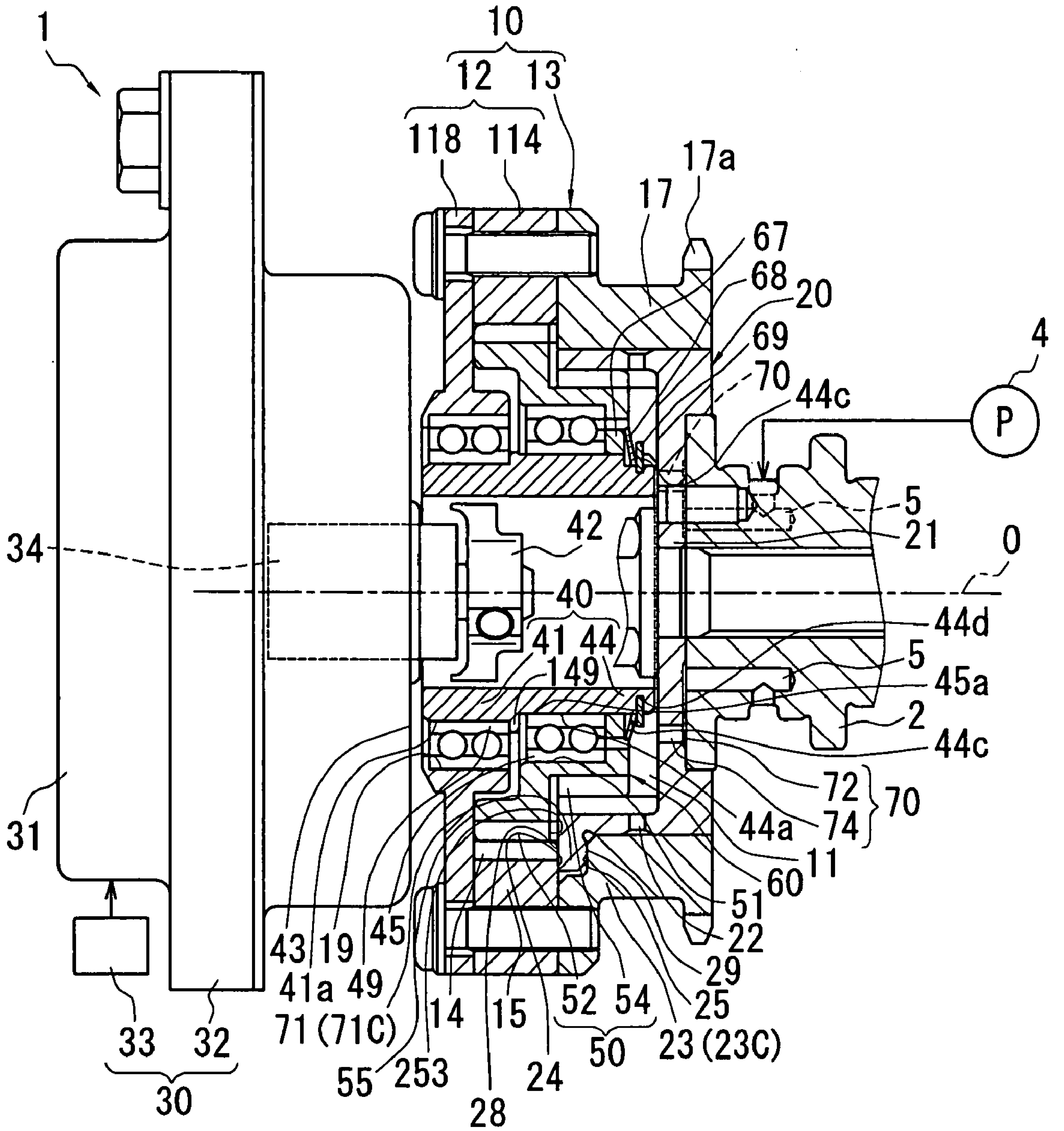
FIG. 14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44c
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23 (23C)
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50
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32
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43
19
45
41a
49
71 (71C)
14
15
55
253
24
28

VALVE TIMING CONTROLLER

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Applications No. 2006-49292 filed on Feb. 24, 2006, and No. 2006-275511 filed on Oct. 6, 2006, the disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a valve timing controller, and particularly to a valve timing controller for an internal combustion engine for controlling a valve timing of at least one of an intake valve and an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft.

BACKGROUND OF THE INVENTION

There is conventionally known a valve timing controller for shifting a relative rotational phase between two rotary elements, which rotate respectively in response to the crankshaft and the camshaft, by a differential gear system composed mainly of a planetary gear.

For example, DE-4110195C2 discloses a valve timing controller which includes a sprocket as one rotary element rotating in response to a crankshaft, and a gear part as the other rotary element rotating in response to the camshaft, having a differential gear system composed mainly of a planetary gear between the sprocket and the other rotary element. Further, a stopper is provided in the sprocket and the gear part for regulating a phase shift angle of a relative rotational phase of the gear part to the sprocket. A planetary motion due to engagement of an internal gear part located in an inner wall of the sprocket and an external gear part located in the planetary gear of the gear part is converted into a relative rotational motion of the gear part to the sprocket. In addition, the gear part moves freely in the thrust direction to the sprocket and is nearly in a free state.

SUMMARY OF THE INVENTION

In the conventional art, the gear part and the sprocket are regulated of their phase shift angles, but the thrust direction movement is not regulated. There is, therefore, a possibility that the gear part and the sprocket are inclined comparatively largely in the thrust direction by transmission of the torque by the planetary motion of the external gear part and the internal gear part. In particular, when the relative rotational movement is performed in high velocity, there is a possibility that a minor irregular friction may be caused by colliding of the gear part with the sprocket. As a result, because of the generation of the minor irregular friction, there may be a possibility that the normal relative rotational movement state is not maintained.

Furthermore, since the gear part and the sprocket collide with each other in a state both of them being in inclined state, as described above, a stress is locally increased at the meshing teeth each other or the like, causing a factor of abrasion or damage.

The present invention is made in view of such circumstances, and an object thereof is to maintain a normal relative rotational movement by a planetary motion even when the relative rotational movement is performed in high velocity in the differential gear system mainly comprised of the planetary gear.

Moreover, another object of the present invention is to provide a valve timing controller capable of maintaining a normal relative rotational movement by the planetary motion, as well as of maintaining a normal operating state of an internal combustion engine, even when the relative rotational movement is operated in high velocity.

According to an aspect of the present invention, a valve timing controller is provided for controlling a valve timing of at least one of an intake valve and an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft.

The valve timing controller has a first rotary element including a first gear part for rotating in response to one of the crankshaft and the camshaft, a second rotary element including a second gear part neighboring to the first gear part in the axial direction for rotating in response to the other of the crankshaft and the camshaft. The valve timing controller has a third rotary element including a third gear part and a fourth gear part. The third gear part and the fourth gear part are meshed respectively with the first gear part and the second gear part. The planetary motion of the third rotary element varies the relative rotational phase between the first rotary element and the second rotary element.

The valve timing controller further comprises a stopper radially extending in either one rotary element of the first rotary element and the second rotary element, for regulating a relative rotational phase shift angle between the first rotary element and the second rotary element. The valve timing controller further comprises an interposing assembler provided either at the other rotary element or between the other rotary element and the third rotary element for relatively rotatably interposing the stopper of the one rotary element in the axial direction.

In this way, it is possible to regulate the thrust direction movement of the one rotary element relative to the other rotary element through the stopper interposed by the interposing assembler in the axial direction, as well as to regulate the relative phase shift angle in these relative rotational movements.

Accordingly, even when the relative rotational movement is performed in high velocity, the normal relative rotational movement state by the planetary motion can be maintained without causing the minor irregular friction between the first rotary element and the second rotary element.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings, in which like portions are designated by like reference numbers and in which:

FIG. **1** is a cross section showing a valve timing controller according to a first embodiment of the present invention;

FIG. **2** is a cross sectional view of the valve timing controller taken along a line II-II in FIG. **1**;

FIG. **3** is a cross sectional view of the valve timing controller taken along a line III-III in FIG. **1**;

FIG. **4** is a cross sectional view showing the valve timing controller taken along a line IV-IV in FIG. **1**;

FIG. **5** is a cross section view showing the valve timing taken along a line V-V in FIG. **1**;

FIG. **6** is a side elevation view showing the valve timing controller;

FIG. **7** is a partial cross section showing a valve timing controller according to a second embodiment of the present invention;

FIG. **8** is a cross section showing a valve timing controller according to a third embodiment of the present invention;

FIG. **9** is a cross section showing a valve timing controller according to a fourth embodiment of the present invention;

FIG. **10** is a cross section showing a valve timing controller according to a fifth embodiment of the present invention;

FIG. **11** is a cross-sectional schematic view for explaining a characteristic portion of the valve timing controller according to the fifth embodiment of the present invention;

FIG. **12** is a cross section showing a valve timing controller according to another embodiment of the present invention;

FIG. **13** is a cross section showing a valve timing controller according to another embodiment of the present invention; and

FIG. **14** is a cross section showing a valve timing controller according to another embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the valve timing controller according to the present invention preferably implemented in a valve timing controller of an internal combustion engine (hereinafter referred to as "engine") will be described with reference to the drawings.

First Embodiment

As shown in FIG. **1**, a valve timing controller **1** is provided in a transmission system which transmits engine torque to a camshaft **2** from a crankshaft of the engine. The valve timing controller **1** adjusts the valve timing of an intake valve of the engine by shifting a relative rotational phase between the crankshaft and the camshaft **2**.

The valve timing controller **1** is provided with a driving-side rotary element **10**, a driven-side rotary element **20**, a control unit **30**, a planetary frame **40**, and a planetary gear **50**.

The driving-side rotary element **10** and the driven-side rotary element **20** jointly form an accommodating space **11** for the planetary frame **40**, the planetary gear **50**, and the like inside thereof.

As shown in FIGS. **1** and **3**, the driving-side rotary element **10** is constituted by coaxially assembling a tubular gear member **12** with a bottom and a two-stepped tubular sprocket **13**. On a peripheral wall part of the gear member **12**, a tip circle forms a driving-side internal gear part **14** existing on the inner peripheral side of a bottom circle. The gear member **12** is fixed by screwing to the sprocket **13** in a state where an outer peripheral wall of the driving-side internal gear part **14** is engaged with the inner peripheral wall of a larger diameter portion **15** of the sprocket **13**. In a step part **17** connecting between the larger diameter portion **15** and a smaller diameter portion **16** in the sprocket **13**, a plurality of teeth **17***a* are provided in a form extruding to the outer periphery side, and an annular timing chain is wound around between these teeth **17***a* and a plurality of teeth of the crankshaft. Therefore, when the engine torque outputted from the crankshaft is inputted into the sprocket **13** through the timing chain, the driving-side rotary element **10** moves with the crankshaft to rotate around a rotational axial line O keeping the relative phase relative to the corresponding axis. The rotational direction of the driving-side rotary element **10** is a counterclockwise direction in the present embodiment as shown in FIG. **3**.

As shown in FIGS. **1** and **4**, the driven-side rotary element **20** is of a tubular type with a bottom, and is coaxially arranged with the driving-side rotary element **10** and the camshaft **2**. A bottom wall part of the driven-side rotary element **20** forms a fixed portion **21** which is fixed by a bolt on an end part of the camshaft **2**. By the bolt fixation, the driven-side rotary element **20** can rotate around the rotational axial line O keeping the relative rotational phase to the corresponding camshaft **2**, moving together with the camshaft **2**, and can rotate relative to the driving-side rotary element **10**. The relative rotational direction toward which the driven-side rotary element **20** advances relative to the driving-side rotary element **10** is called advance direction X. The relative rotational direction toward which the driven-side rotary element **20** retards relative to the driving-side rotary element **10** is called retard direction Y.

The peripheral wall part of the driven-side rotary element **20** has a driven-side internal gear part **22**, in which the tip circle exists on the inner periphery side of the bottom circle, formed thereon. Here, the inside diameter of the driven-side internal gear part **22** is set smaller than the inside diameter of the driving-side internal gear part **14**. The number of the teeth of the driven-side internal gear part **22** is set smaller than the number of the teeth of the driving-side internal gear part **14**. The outer peripheral wall of the driven-side internal gear part **22** is engaged with the smaller diameter portion **16** and the inner peripheral wall of the step part **17** in the sprocket **13**, thereby the driven-side rotary element **20** relatively rotatably supports the driving-side rotary element **10** from the inner periphery side.

In the driven-side internal gear part **22**, a flange part **23** protruding toward the outer periphery side is provided on an end part opposite to the fixed portion **21**. The flange part **23** is interposed tightly between an end surface **24** of the driving-side internal gear part **14** and an end surface **25** of the step part **17**, which oppose with each other in the axial direction. By this tightly interposed form, in the driven-side internal gear part **22**, both surfaces **28** and **29** of the flange part **23** relatively rotatably contact with the end surfaces **24** and **25** facing toward the axial direction of the driving-side rotary element **10**. The driven-side internal gear part **22** neighbors the driving-side internal gear part **14** with a deviation in the axial direction in a state where the axial direction relative displacement is regulated. The flange part **23** regulates the axial relative displacement and the relative rotational direction displacement of the driven-side internal gear part **22**.

It should be noted that a structure of the flange part **23** which regulates the axial relative displacement and relative rotational direction displacement of the driven-side internal gear part **22** will be described later.

As shown in FIG. **1**, a control unit **30** is comprised of an electric motor **32**, an electric current control circuit **33**. The electric motor **32** is arranged on the opposite side of the camshaft **2** with respect to the rotary elements **10** and **20**. The electric motor **32** is an electric motor, for example, a brushless motor and the like, and includes a motor case **31** fixed to the engine via a stay (not shown) and a motor shaft **34** supported rotatably in direct and reverse directions by the motor case **31**.

The electric current control circuit **33** is formed of an electric circuit such as a microcomputer and the like, is arranged outside or inside of the motor case **31**, and is electrically connected with the electric motor **32**. The electric current control circuit **33** controls an electric current flow to a coil (not shown) of the electric motor **32** in accordance with an operating condition and the like of the engine. By the electric current control, the electric motor **32** forms a rotating magnetic field around the motor shaft **34**, and outputs rotating torque in the directions X and Y (refer FIG. **5**) in accordance with the direction of the rotating magnetic field from the motor shaft **34**.

As shown in FIGS. **1** and **5**, an input part **41** of the planetary frame **40** is of a tubular type coaxial with the rotary elements

10, 20 and shafts 2, 34, and is fixed to the motor shaft 34 via a joint 42. By this fixing, the planetary frame 40 can rotate around the rotational axial line O moving together with the motor shaft 34, and can rotate relative to the driving-side rotary element 10. The input part 41 is arranged on the inner periphery side of a center hole 19 which axially penetrates through the bottom wall part 18 of the gear member 12, and supports the driving-side rotary element 10 through a bearing 43 from the inner periphery side of the center hole 19.

As shown in FIGS. 1 and 3, in the planetary frame 40, an eccentric part 44 which locates closer to the fixed part 21 than the input part 41 is of a tubular type in which the outer periphery wall is off-set relative to the rotary elements 10, 20 and shafts 2, 34. The eccentric part 44 is arranged on the inner periphery side of the center hole 51 which axially penetrates through the planetary gear 50, and supports the planetary gear 50 through the bearing 45 from the inner periphery side of the center hole 51. By this supporting, the planetary gear 50 can rotate around the eccentric axial line P which is the central axial line of the outer periphery wall of the eccentric part 44, and can rotate toward the rotational direction of the eccentric part 44. In other words, the planetary gear 50 is arranged to be capable of performing the planetary motion.

As shown in FIGS. 1 to 4, the planetary gear 50 is of a two-step tubular type, and the tip circle forms the driving side external gear part 52 and the driven side external gear part 54 existing on the outer periphery side of the bottom circle respectively by the larger diameter portion and the smaller diameter portion. Here, the number of the teeth of the driving side external gear part 52 is set smaller by a predetermined number N (one, in this embodiment) than the number of the teeth of the driving-side internal gear part 14. The number of the teeth of the driven side external gear part 54 is set smaller by the predetermined number N than the driven-side internal gear part 22. Accordingly, the number of the teeth of the driven side external gear part 54 is smaller than the number of the teeth of the driving side external gear part 52. The driving side external gear part 52 is arranged on the inner periphery side of the driving-side internal gear part 14, and meshed with a part of the gear part 14. Further, the driven side external gear part 54 which is located closer to the fixed part 21 than the driving side external gear part 52 is arranged on the inner periphery side of the driven-side internal gear part 22, and meshed with a part of the gear part 22.

Furthermore, as shown in FIG. 1, the eccentric part 44, which supports the planetary gear 50 through the bearing 45 from the inner periphery side of the center hole 51 are engaged with the bearing 45 by an clearance inlay. A clearance is formed between the outer periphery 44*a* of the eccentric part 44 and the inner periphery 45*a* of the bearing 45. Accordingly, the driving side external gear part 52 and the driven side external gear part 54 are movable in the axial direction between the driving-side internal gear part 14 and the driven-side internal gear part 22. The planetary gear 50 regulates a movement in one direction in the axial direction (left side in FIG. 1) by an engagement part 49 provided in the planetary frame 40 through the bearing 45.

It should be noted that in the embodiment described hereinafter, the planetary gear 50 and the bearing 45 are supported by the planetary frame 40 in a state the bearing 45 is contacted on the engagement part.

Further, on the opposite end of the engagement part 49 of the planetary gear 50, an engagement member 69 such as a snap ring or the like is provided on the outer periphery 44*a* of the planetary frame 40 through a spacer 67. The planetary gear 50 and the spacer 67 are interposed in the axial space between the engagement part 49 and the engagement member 69, for forming an axial clearance (thrust clearance) in the axial space. By selecting an axial width of the spacer 67 at a predetermined width, the axial clearance (thrust clearance) is formed as a prescribed clearance.

It should be noted here that two guide holes 70 are formed on the fixed part 21 to guide a lubricating oil for the engine which is a lubricating fluid into an inside space 11 of the rotary elements 10 and 20, as shown in FIGS. 1 and 6. These guide holes 70 are respectively provided at two locations which are symmetrical each other with respect to the rotational axial line O, and are arranged at equal intervals in the circumferential direction of the fixed part 21 which coincides with the common circumferential direction of the internal gear parts 14 and 22. At respective guide holes 70, upstream side orifice parts 72 are long and in a flat slotted-hole shape in the radial direction of the fixed part 21. Here, the entrance parts of the orifice part 72 are communicated with a corresponding one out of two supply holes 5 to which the lubricating oil is discharged for supplying from a pump 4 in the camshaft 2, and a flow-path area of the orifice part 72 is more reduced than the flow-path area of the corresponding supply hole 5.

Furthermore, a guide part 74 located at the downstream side of the orifice part 72 in each guide hole 70 is in a tubular-hole shape extending in the axial direction of the fixed part 21. Here, an outlet part of the guide part 74 is open further toward the inner peripheral side than a tip circle 86 of the driven-side internal gear part 22, thereby communicating with the inside spaces 11 of the rotary elements 10 and 20.

As shown in FIGS. 1, and 5, in the gear member 12, nine discharge holes 80 for discharging the lubricating oil to the outside from the inside spaces 11 are formed at a bottom wall part 18 located at the opposite side of the fixed part 21 interposing the differential gear system 60. These discharge holes 80 are mutually arranged with prescribed intervals in the circumferential direction of the bottom wall part 18 which coincides with the common circumferential direction of the internal gear parts 14 and 22, and respectively exhibit tubular hole shape penetrating through the bottom wall part 18 in the axial direction. Here, the outlet part of the discharge hole 80 is open toward the outside space between the bottom wall part 18 and the electric motor 32. Moreover, the entrance part of the discharge hole 80 is open toward a tooth groove 88 of the driving-side internal gear part 14, thereby communicating with the inside space 11.

By the arrangement described above, in the inside space 11 of the rotary elements 10 and 20, the differential gear system 60 which is formed by combining the driving-side internal gear part 14 with the driven-side internal gear part 22 through the planetary gear 50 is formed on the outer periphery side of the eccentric part 44. Then, in the differential gear system 60, when the planetary frame 40 does not rotate relative to the driving-side rotary element 10, the planetary gear 50 rotates together with the rotary elements 10 and 20 while maintaining meshed positions of the external gear parts 52 and 54 with the internal gear parts 14 and 22. As a result, the relative rotational phase between the rotary elements 10 and 20 is maintained, thus the valve timing is also maintained. On the other hand, when the planetary frame 40 is rotated in the advance direction X with an increase of the rotational torque in the X direction, the driven-side rotary element 20 rotates in the advance direction X.

Accordingly, the valve timing is shifted toward the advance side. Furthermore, when the planetary frame 40 is relatively rotated in the retard direction Y due to the increase of the rotational torque in the Y direction and an abrupt stop of the electric motor 32, the driven-side rotary element 20 rotates in the retard direction Y relative to the driving-side rotary element **10**, by operating the planetary gear **50** in the planetary motion while shifting the meshing positions of the external gear parts **52** and **54** with the internal gear parts **14** and **22**. Accordingly, when the valve timing is shifted toward the retard side, and particularly when the electric motor **32** is abruptly stopped, the valve timing of the most retard phase which enables starting of the internal combustion engine can be realized.

A characteristic portion of the valve timing controller **1** will be described in more detail.

A flange part **23** of the driven-side internal gear part **22** is, as shown in FIGS. **1** and **2**, constituted of circular protrusion parts (hereinafter referred to as "stoppers") **23**A, **23**B, and **23**C in the circumferential direction.

As shown in FIGS. **1** and **2**, a flange groove **71** extending in the circumferential direction along the inner periphery thereof is provided on the inner periphery part of the inner wall of the driving-side rotary element **10**. The flange groove **71** is circularly open toward the outer periphery of the driven-side internal gear part **22**, as shown in FIG. **2**. The flange groove **71** is constituted of three pieces of the circular guide grooves (hereinafter referred to as "stopper grooves") **71**A, **71**B, and **71**C which interposes the respective stoppers **23**A, **23**B, and **23**C in the opening part.

In particular, the respective stopper grooves **71**A, **71**B, and **71**C are formed, as shown in FIG. **1**, on the inner periphery of the step part **17** of the sprocket **13** in the driving-side rotary element **10** having the gear member **12** and the sprocket **13**. The respective stopper grooves **71**A, **71**B, and **71**C are, as shown in FIGS. **1**, **2**, and **4**, formed by being partitioned by the axial end surface **25** of the groove and an axial end surface **24** of the driving-side internal gear part **14**. As a result, the axial end surface **24** of the driving-side internal gear part **14** can be used as a thrust receiving surface of the stoppers **23**A, **23**B, **23**C, while having the driving-side internal gear part **14**, of the driving-side rotary element **10** neighbored in the axial direction to the driven-side internal gear part **22** having the stoppers **23**A, **23**B, **23**C of the driven-side rotary element **20**. Accordingly, when the driving-side rotary element **10** is formed by assembling the gear member **12** with the sprocket **13**, the stoppers **23**A, **23**B, and **23**C of the driven-side rotary element **20** can be easily interposed.

However, the stoppers **23**A, **23**B, and **23**C preferably extend circularly along the relative rotational direction of the driving-side rotary element **10** and the driven-side rotary element **20**. Thereby the relative rotational phase of the driving-side rotary element **10** relative to the driven-side rotary element **20** can be smoothly shifted within the range of the relative rotational shift angle.

Further, the stoppers **23**A, **23**B, and **23**C are arranged over the circumferential direction, and thereby the thrust direction movement of the driven-side rotary element **20** having the stoppers described above can be stably regulated relative to the driving-side rotary element **10**.

When the multiple stoppers described above are arranged over the circumferential direction, it is preferable that the stoppers **23**A, **23**B, and **23**C are arranged substantially at equal intervals over the entire circumference. Thereby the thrust clearance, which indicates a thrust direction movement quantity of the driven-side rotary element **20** relative to the driving-side rotary element **10**, can be made uniform over the entire circumference in the relative rotational direction.

The respective stoppers **23**A, **23**B, and **23**C protrude in the inside of the stopper grooves **71**A, **71**B, and **71**C, and extend shorter than the lengths in the circumferential direction of the respective stopper grooves **71**A, **71**B, and **71**C, which are formed in predetermined circular shapes. The respective stoppers **23**A, **23**B, and **23**C are movable in the circumferential direction in the respective stopper grooves **71**A, **71**B, and **71**C, and are capable of shifting the relative rotational phases relative to the respective stopper grooves **71**A, **71**B, and **71**C.

The shifting possible angle of the relative rotational phase (hereinafter referred to as "relative rotational phase shift angle") of each stopper **23**A, **23**B, **23**C relative to each stopper groove **71**A, **71**B, **71**C is determined by the difference in the circumferential length between the stopper groove **71**A, **71**B, **71**C and each stopper **23**A, **23**B, **23**C.

However, in the relatively rotating rotary elements **10**, **20**, the respective stoppers **23**A, **23**B **23**C may simultaneously collide with the circumferential end surfaces of the respective stopper grooves **71**A, **71**B, **71**C in the advance direction X and the retard direction Y. Alternatively, one pair out of respective pairs of the stoppers **23**A, **23**B, **23**C and the stopper grooves **71**A, **71**B, **71**C may collide therebetween.

In the description of the embodiment hereinafter, one pair composed of the stopper **23**C and the stopper groove **71**C collides in the advance direction X and the retard direction Y. As shown in FIG. **2**, in a case that the clearances of the circumferential direction length between the stoppers **23**A, **23**B, **23**C and the stopper grooves **71**A, **71**B, **71**C are set at δay, δby, and δcy in the retard direction Y, the clearances δay, δby, and δcy are set such that, when it is set at $\delta cy=0$ where the stopper **23**C collides with the stopper groove **71**C, other pairs are set to have the clearances expressed by $\delta ay>0$ and $\delta by>0$. Furthermore, similarly, in the advance direction X, if they are set at δax, δbx, and δcx, when it is set at $\delta cx=0$ where the stopper **23**C collides with the stopper groove **71**C, the other pairs are set to have the clearances expressed by $\delta ax>0$ and $\delta bx>0$.

In this way, the stopper **23**C and the stopper groove **71**C regulate the relative phase shift angle in the relative rotational movement of the driving-side rotary element **10** and the driven-side rotary element **20**.

It should be noted that the sizes of the clearances between δay and δby, and δax and δbx may have values which are substantially the same or different. Furthermore, the difference of δay, the difference between δby and δay, the difference of δax and the difference between δbx and δax are preferably set within a range of a predetermined difference. Thereby, in addition to the pair of the stopper **23**C and the stopper groove **71**C, even in other pairs of the stoppers **23**A and **23**B of the stopper grooves **71**A and **71**B, a function of regulating the relative phase shift angle in the relative rotational movement of the element **10** and the element **20** can be achieved. Accordingly, with the stoppers **23**A, **23**B, **23**C and the stopper grooves **71**A, **71**B, **71**C in these pairs, reliability of the function of regulating the relative phase shift angle described above can be improved.

Even if there is a case where, for example, the stopper **23**C of one pair are damaged or the like, since the relative phase shift angle can be regulated by the stoppers **23**A and **23**B of the other pairs, normal operating state of the engine can be maintained. It should be noted that, here, the predetermined difference means a prescribed difference which can maintain the normal operating state of the engine, even when a deviation of the relative rotational shift angle is caused by the difference of δay, and the difference with δax.

Moreover, in the embodiment, the respective stoppers **23**A, **23**B, **23**C are preferably arranged substantially at equal intervals over the entire circumferential in the relative rotational direction.

Furthermore, in the embodiment, an urging member **68** for urging the planetary gear **50** toward the engagement part **49** is preferably provided. In particular, the urging member **68** is formed of a spring member, for example, a coned disc spring or the like, and is interposed between the spacer **67** and the engagement member **69**. In the following description of the present embodiment, the coned disc spring is used as the urging member **68**.

The urging member **68** is formed on the substantially annular-shaped coned disc spring, and the inner periphery **68**a thereof is removably mounted on an outer periphery **44**c for engagement use formed on a right end side of the outer periphery **44**a of the eccentric part **44**. Further, the engagement member **69** is arranged to be mounted on the step part **44**d formed on the outer periphery **44**c, and the urging member **68** is interposed between the spacer **67** and the engagement member **69**, namely in an axial clearance (thrust clearance), by mounting and engaging the engagement member **69** to the step part **44**d. As a result, the axial clearance (thrust clearance) is buried by spring deflection of the urging member **68**.

In the embodiment described above, on the sprocket **13** of the driving-side rotary element **10**, a thrust groove **71**C is provided to accommodate the driven-side rotary element **20** so as to relatively rotate thereto and interposes the driven-side internal gear part **22** in the axial direction. On the driven-side internal gear part **22**, the stopper **23**C is provided to circularly extend along the inside of the thrust groove **71**C and enable a predetermined relative phase shift angle.

By such arrangement, the relative phase shift angle in the relative rotational movement of the element **10** and the element **20** is regulated by the stopper **23**C and the thrust groove **71**C. The thrust direction movement of the driven-side rotary element **20** relative to the driving-side rotary element **10** can be regulated through the stopper **23** circularly extending along the inside of the thrust groove **71**C.

Accordingly, even when the relative rotational movement is performed in high velocity, the minor irregular friction between the driving-side rotary element **10** and the driven-side rotary element **20** does not occur, and the normal relative rotational movement state by the planetary motion can be maintained.

Furthermore, in the embodiment, the stopper groove **71**C is arranged to have an opening so as to extend in the circumferential direction along the inner periphery part of the driving-side rotary element **10**. Hence, it can be made as the guide groove of a circular type, which opens within a predetermined circumferential range along the inner periphery of the inner peripheral part of the driving-side rotary element **10**. Thereby the relative rotational movement can be regulated on the circumferential end surface inside the thrust groove **71**C relative to the stopper **23**C which relatively rotates along the inside of the thrust groove **71**C. The relative phase shift angle in the relative rotational movement can be regulated by the stopper **23**C and the thrust groove **71**C.

Moreover, in the embodiment, a plurality of the pairs of the thrust grooves **71**A, **71**B, **71**C and the stoppers **23**A, **23**B, **23**C are preferably provided (three pairs in the embodiment).

Consequently, in addition to the pair of the stopper **23**C and the stopper groove **71**C described above, even in the other pairs of the stoppers **23**A, **23**B and the stopper grooves **71**A, **71**B, the function of regulating the relative phase shift angle in the relative rotational movement of the driving-side rotary element **10** and the driven-side rotary element **20** can be achieved. Accordingly, the stoppers **23**A, **23**B, **23**C and the stopper grooves **71**A, **71**B, **71**C of these pairs can improve the reliability of the function of regulating the relative phase shift angle described above. Even if there is a case where the stopper **23**C of the one pair is damaged, the normal operating state of the engine can be maintained, since the relative phase shift angle can be regulated by the stoppers **23**A, and **23**B of the other pairs.

Further, in this case, it is preferable that a function to detect a deviation relative to the predetermined relative phase shift angle is provided on the control device such as the control unit **30**. Thereby the deviation described above which is caused by the fact that the relative phase shift angle is regulated by at least one of the stopper **23**A and the stopper **23**B of the other pairs, can be detected and thus a failure such as damage of the stopper **23**C can be detected.

Furthermore, in the plurality of pairs of the thrust grooves **71**A, **71**B, **71**C, and the stopper **23**A, **23**B, **23**C, respective stoppers **23**A, **23**B, **23**C are preferably arranged at substantially equal intervals over the entire circumference in the relative rotational direction. Thereby the thrust clearance indicating the thrust direction movement quantity of the driven-side rotary element **20** relative to the driving-side rotary element **10** can be made uniform over the entire circumference in the relative rotational direction.

Moreover, in the embodiment, respective stopper grooves **71**A, **71**B, **71**C are formed on the inner periphery of the step part **17** of the sprocket **13** in the driving-side rotary element **10** having the gear member **12** and the sprocket **13**, which is dividable into two in the axial direction. The respective stopper grooves **71**A, **71**B, **71**C are formed so as to be defined by the axial end surfaces **25** of the grooves thereof and the axial direction end surfaces **24** of the driving-side internal gear part **14**. Accordingly, the axial end surface **24** of the driving-side internal gear part **14** can be used as the thrust receiving surface of the stoppers **23**A, **23**B, **23**C, while neighboring the driving-side internal gear part **14** to the driven-side internal gear part **22** having the stoppers **23**A, **23**B, and **23**C in the axial direction. By such arrangement, a relatively simple, two-dividable structure can be made as a division assembling structure for providing the thrust groove, while dividing the driven-side rotary element **20** into two parts in the axial direction.

Accordingly, when the driving-side rotary element **10** is formed by assembling the gear member **12** and the sprocket **13**, the stoppers **23**A, **23**B, **23**C of the driven-side rotary element **20** can be easily interposed.

In the embodiment described above, the driving side external gear part **52** and the driven side external gear part **54** of the planetary gear **50** are provided with the planetary frame **40** which enables axial movement between the driving-side internal gear part **14** and the driven-side internal gear part **22** inside the rotary elements **10**, **20**. However, they may be structured so as to provide the urging member **68** which is disposed in the thrust clearance (hereinafter referred to as "second thrust clearance") existing between the planetary frame **40** and the planetary gear **50**. Accordingly, when the external gear parts **52** and **54** are integrally operated in the planetary motion while meshing the external gear parts **52**, **54** with the internal gear parts **14**, **22**, the thrust direction movement of the planetary gear **50** can be effectively restrained by the urging member **68**.

Further, in the embodiment, since the planetary gear **50** is urged by the urging force of the urging member **68** so as to remove the second thrust clearance described above, the second thrust clearance can be set within an clearance range in which the urging force of the urging member **68** is generated. Therefore, it is not necessary to increase the part processing precision in order to make the second thrust clearance smaller.

Furthermore, the embodiment is structured so as to interpose the planetary gear **50** between the engagement part **49** and the urging member **68**, and thus the urging force of the urging member **68** can be surely added to the planetary gear **50**. Accordingly, the thrust movement of the planetary gear **50** performing an eccentric movement can be effectively restrained by the urging force generated in the urging member **68**.

Second Embodiment

Hereinafter, descriptions are made about other embodiments to which the present invention is applied. In the embodiments described hereunder, components identical or equivalent to those in the first embodiment are referred to as identical numerals and the descriptions thereof are not repeated.

The first embodiment is described such that the stoppers **23**A, **23**B, and **23**C of the driven-side rotary element **20** are directly interposed between the gear member **12** and the axial end surfaces **24** and **25** of the sprocket **13**.

Contrary to this, the second embodiment is, as shown in FIG. **7**, structured such that a clearance adjusting member **90** is provided to be interposed into a clearance between the axial end surface **25** and the stoppers **23**A, **23**B, and **23**C in a space between the axial end surfaces **24** and **25** above described. FIG. **7** is a partial Gross section showing the valve timing controller according to the second embodiment.

As shown in FIG. **7**, the clearance adjusting member **90** such as an annular shim or the like is provided in a clearance between the axial direction end surface **24** of the driving-side internal gear part **14** and the stopper **23**C. The clearance adjusting member **90** is interposed in an axial space between the axial end surface **24** and the axial end surface **25** through the stopper **23**C. The clearance adjusting member **90** forms a thrust clearance in the axial space.

Even if thus arranged, the same advantages as the first embodiment can be obtained.

Further, in the embodiment, the thrust clearance can be formed in a prescribed clearance by selecting an axial width of the clearance adjusting member **90** in a predetermined width, making it unnecessary to increase the part processing precision for making the second thrust clearance smaller.

Furthermore, the second embodiment is structured such that the clearance adjusting member **90** is interposed in the axial end surface **24** of the driving-side internal gear part **14**. The clearance adjusting member **90** can be formed in a simple shape such as an annular shape, since the thrust receiving surface thereof is not influenced by the shape of the thrust grooves **71**A, **71**B, **71**C.

Third Embodiment

In the first embodiment, the thrust direction movement of the driven-side rotary element **20** relative to the driving-side rotary element **10** through the stopper **23** is regulated by interposing the stopper **23** into the thrust groove **71** formed along the inner periphery part of the driving-side rotary element **10** in the axial direction.

Alternatively, in the third embodiment, as shown in FIG. **8**, the stopper **23** is arranged to be interposed by the planetary gear **50** in a state the stopper **23** is accommodated in the thrust groove **71**.

The stoppers **23**A, **23**B, **23**C of the driven-side rotary element **20** are guided to the thrust grooves **71**A, **71**B, **71**C of the driving-side rotary element **10**, and are accommodated in the respective thrust grooves **71**A, **71**B, and **71**C. It should be noted that only one pair of the stopper **23**C and the thrust grooves **71**C is shown in FIG. **8**. Hereinafter, description is made of the one pair of the stopper **23**C and the thrust groove **71**C, and the descriptions of the other pairs are omitted.

As shown in FIG. **8**, an axial direction end surface **124** of the driving-side internal gear part **14** out of the axial direction end surfaces **124** and **25** of the thrust groove **71**C is spaced from the stopper **23**C in order not to contact with the end surface **128** of the stopper **23**C. Further, the axial end surface **53** of the driving side external gear part **52** of the planetary gear **50** is arranged so as to be contactable on the end surface **128** of the stopper **23**C.

In other words, an clearance between the axial end surface **53** and the end surface **128** is set smaller than the clearance between the axial end surface **124** and the end surface **128**. The axial end surface **53** serves as a thrust receiving surface of the stopper **23**C.

By such arrangement, the stoppers **23**A, **23**B, **23**C can be interposed in the axial direction by the interposing assembler composed of the driving-side rotary element **10** and the planetary gear **50**. In other words, the stopper **23**A, **23**B, **23**C can be interposed in the axial direction by the thrust grooves **71**A, **71**B, **71**C, and the axial end surface **53** of the planetary gear **50**. The advantage which is the same as that of the first embodiment can be also obtained even in such arrangement described above.

Furthermore, in the third embodiment, the planetary gear **50** (in detail, the axial end surface **53** of the driving side external gear part **52**) achieves the function of the thrust-receiving surface of the stoppers **23**A, **23**B, **23**C in the planetary gear **50** accommodated between the element **10** and the element **20**. A predetermined clearance can be secured between the planetary frame **40** of the planetary gear **50** and the fixed part **21** of the driven-side rotary element **20**, as shown in FIG. **8**.

Moreover, the third embodiment is preferably structured so as to provide the urging member **68** for reducing the thrust clearance existing between the planetary frame **40** and the planetary gear **50**. Thereby the planetary gear **50** having the external gear parts **52** and **54** is restrained of its thrust direction movement by the urging member **68** when the external gear parts **52** and **54** perform the planetary motion in integration while meshing the external gear parts **52** and **54** with the internal gear parts **14** and **22**.

Fourth Embodiment

In the third embodiment, the thrust receiving surface of the planetary gear **50** which interposes the stoppers **23**A, **23**B, and **23**C is formed of the axial direction end surface **53** of the driving side external gear part **52**.

Alternatively, in a fourth embodiment, the function of the thrust receiving surface described above is provided, as shown in FIG. **9**, on an extension part **56** which is provided as extending between the driving side external gear part **52** and the driven side external gear part **54**. It should be noted that, FIG. **9** shows only one pair composed of the stopper **23**C and the thrust groove **71** C out of the stoppers described above for drawing composition. Hereinafter, description is made of the one pair of the stopper **23**C and the thrust groove **71**C, omitting the descriptions of the other pairs.

As shown in FIG. **9**, in the planetary gear **50**, an extension part **56** extends between the driving side external gear **52** and the driven side external gear part **54** in the radial direction. The extension part **56** is provided between the driving side external gear part **52** and the driven side external gear part **54**. The extension part **56** extends in the radial direction along both surfaces **124** and **128** of the thrust groove **71**C.

An axial end surface **57** of the extension part **56** is arranged to be able to contact with the axial end surface **128** of the stopper **23**C, and constitutes the thrust-receiving surface of the stopper **23**C.

Even if thus arranged, the same advantages as the third embodiment can be obtained.

Fifth Embodiment

A fifth embodiment is a modification of the third embodiment. As shown in FIG. **10**, in the fifth embodiment, as is similar to the third embodiment, an axial end surface **200** of the driven-side internal gear part **22** including the end surface **128** contacts on the axial end surface **53**. A micro thrust clearance is formed between the end surfaces **53** and **200**. The planetary gear **50** and the driven-side rotary element **20** can rotate relatively with each other.

Further, as shown in FIG. **10**, in the fifth embodiment, an outer race **210** of the bearing **45** is press-fitted into the inner periphery side of a center hole **51** of the planetary gear **50**. An inner race **212** of the bearing **45** is engaged with the outer periphery side of the eccentric part **44** of the planetary frame **40**. Thereby, the planetary gear **50** and the bearing **45** are integrated to form a planetary rotary element **220**. The planetary rotary element **220** is supported by the planetary frame **40** in a state where a micro clearance is formed between the outer periphery **44***a* of the eccentric part **44** and the inner periphery **45***a* of the inner race **212** of the bearing **45**.

Furthermore, as shown in FIG. **11**, in the fifth embodiment, the planetary frame **40** supports the planetary rotary element **220** on an projection line L**1** where a tooth bearing center C**1** in the axial direction of the driven-side internal gear part **22** and the driven side external gear part **54** is projected in the radial direction. Moreover, also on a projection line L**2** where a tooth bearing center C**2** in the axial direction of the driving-side internal gear part **14** and the driving side external gear part **52** is projected in the radial direction, the planetary frame **40** supports the planetary rotary element **220**. As a result, the supporting portion of the planetary rotary element **220** in the planetary frame **40** is surely positioned on the inner periphery side of both of the tooth bearing centers C**1** and C**2**. It should be noted that in a schematic cross section of FIG. **11**, in order to make understanding of a characteristic portion easier, a hatching, which shows a cross section, is omitted for convenience.

In the supporting form of such characteristics, a radial load F**1** generated by engagement between the gear parts **22** and **54** acts on the planetary rotary element **220** along the projection line L**1** of the tooth bearing center C**1**, as shown in FIG. **11**. Further, a radial load F**2** generated by engagement between the gear parts **14** and **52** acts on the planetary rotary element **220** along the projection line L**2** of the tooth bearing center C**2**. Here, a reactive force F**3** which balances with both of the radial loads F**1** and F**2** is given to the planetary rotary element **220** from the planetary frame **40**, since the supporting portion of the planetary rotary element **220** in the planetary frame **40** is positioned on the inner periphery side of the centers C**1** and C**2**. As a result, the planetary rotary element **220** becomes more difficult to incline relative to the normal axial direction substantially parallel with the rotational axial line O. Therefore, generation of the thrust load can be restrained between the gear parts **22**, **54** and the gear parts **14**, **52**.

Moreover, the axial end surface **53** of the driving side external gear part **52** of the planetary gear **50** which comprises the planetary rotary element **220** is contacted on an axial end surface **200** of the driven-side internal gear part **22**. The inclination of the planetary rotary element **220**, and even generation of the thrust loads between the gear parts **22** and **54** as well as between the gear parts **14** and **52** can also be restrained.

As described above, in the fifth embodiment, generation of the thrust load between the gear parts **22** and **54** or between the gear parts **14** and **52** is restrained, and thereby shortening of the lifetime of the bearing **45** subject to such thrust load can be prevented. Further, due to the thrust load generation restraining action, it becomes unnecessary to provide a dislocation-stopper of the bearing **43** on a portion encircled by a dotted line **230** in FIG. **11** in the bottom wall part **18** of the gear member **12**. According to the fifth embodiment, a reduction in size in the axial direction, a reduction in production cost can be realized, simultaneously with high durability.

In addition, in the fifth embodiment, the planetary motion of the planetary rotary element **220** is performed without obstruction because of the restraining of the inclination of the planetary rotary element **220**, thereby causing maintenance of the normal relative rotational movement state by the planetary motion.

Other Embodiment

The present invention can be applied and implemented in a variety of embodiments within the scope without departing from the spirit of the present invention.

(1) In the embodiment above described, description is made of the valve timing controller **1** for adjusting valve timing of the intake valve. The present invention may also be applied to a device for adjusting valve timing of the exhaust valve, and a device for adjusting the valve timing of both of the intake valve and the exhaust valve. Besides, in the embodiment above described, description is made of the valve timing controller **1** in which the rotary element **10** is linked to a motion of the crankshaft and the rotary element **20** is linked to a motion of the camshaft **2**. However, it may be arranged such that the rotary element **10** is linked to a motion of the camshaft **2** and the rotary element **20** is linked to a motion of the crankshaft.

(2) Besides, in the embodiment above described, the driving-side internal gear part **14** and the driven-side internal gear part **22** which are neighbored in the axial direction are mutually contacted. However, the present embodiment is not limited thereto. These driving-side internal gear part **14** and driven-side internal gear part **22** may be arranged in the axial direction with a clearance therebetween.

(3) Besides, the embodiment above described is provided with the urging member **68** for urging the planetary gear **50** toward the support member (planetary frame) **40** for axially movably supporting. The embodiment is not limited thereto. The urging member **68** may not be provided.

(4) Besides, the embodiment above described is structured such that the stoppers **23**A, **23**B, **23**C are provided as extending on the driven-side rotary element **20**, and the thrust grooves **71**A, **71**B, and **71**C are formed on the driving-side rotary element **10**. The embodiment is not limited thereto. The stopper **2** may be provided as extending on the driving side rotary element, and the thrust groove may be formed on the driven side rotary element.

(5) Besides, the embodiment described above is structured such that the interposing assembler for interposing the stoppers **23**A, **23**B, **23**C in the axial direction is provided on the driving-side rotary element **10** for interposing them into the thrust grooves **71**A, **71**B, and **71**C. Alternatively, the interposing assembler is provided on the driving-side rotary element **10** and the planetary gear **50** for interposing it by the end surfaces **53** and **57** of the planetary gear **50** and the thrust

grooves **71**A, **71**B, **71**C. However, the embodiment is not limited to such arrangements. As long as there is provided an interposing assembler which relatively rotatably interposes the stopper extending on either one of the element **10** and the element **20** in the axial direction, any structure of the interposing assembler provided either on the other rotary element or between the other rotary element and the planetary gear may be used.

(6) Besides, in the embodiment described above, a plurality of pairs of the stoppers **23**A, **23**B, **23**C of the stopper grooves **71**A, **71**B, **71**C are provided. However, the embodiment is not limited thereto. A plurality of stoppers may be provided irrespective of the number of the stopper grooves (refer to FIG. **12**). In this case, the plurality of stoppers can be provided at equal intervals in the relative rotational direction. Even with such arrangement, the thrust clearances indicating the thrust direction movement quantity of the driven-side rotary element **20** relative to the driving-side rotary element **10** can be made uniform over the entire periphery in the relative rotational direction.

(7) Besides, the embodiment described above is structured to include the dividing rotary element for dividing the driving-side rotary element **10** into two pieces in the axial direction and define the thrust groove by the axial end surface **24** of the driving-side internal gear part **14** of the fixed member **13** which is the one dividing rotary element. The structure is not limited thereto. The dividing rotary element may be of any structure so long as the thrust groove is defined by the two axial end surfaces of the dividing rotary element.

(8) Further, in the second embodiment described above, the clearance adjusting member **90** is provided in the clearance between the axial end surface **24** of the driving-side internal gear part **14** and the stopper **23**C. The structure is not limited thereto. The clearance adjusting member **90** may be a clearance between any of the axial end surfaces and the stopper part **14** so long as the axial end surfaces of the dividing rotary element is used.

(9) Furthermore, in the embodiment above described, the gear member **12** including the driving side inside gear part **14** and the bottom wall part **18** is screwed on the sprocket **13** in a state where the driving side inside gear part **14** and the bottom wall part **18** are formed in integration. The outer circumference wall of the driving side inside gear part **14** is engaged with the inner circumference wall of the larger diameter portion **15** of the sprocket **13**. The gear member **12** is not limited to the one formed by the driving side inside gear part **14** and the bottom wall part **18** in integration, and may be structured so as to form the driving side inside gear part and the bottom wall part as separate parts. For example, as shown in FIG. **13**, the gear member **12** may be structured such that the driving side inside gear part **114** and the bottom wall part **118** are formed with separate members. The driving side inside gear part **114** is interposed and screwed between the bottom wall part **18** and the larger diameter portion **15** of the sprocket **13**.

(10) Moreover, in the embodiment described above, the stoppers **23**A, **23**B, **23**C of the driven-side rotary element **20** are interposed in the axial direction by the thrust grooves **71**A, **71**B, **71**C provided on the sprocket **13** as the driving-side rotary element **10** and the axial end surface **53** of the driving side external gear part **52** as the planetary gear **50**. The planetary gear **50** contacts with the engagement part **49** provided on the planetary frame (supporting member) **40** through the bearing **45**. The axial end surface **53** of the driving side external gear part **52** effectively achieves the function of the thrust-receiving surface of the stoppers **23**A, **23**B, **23**C.

In contrast, for example, as shown in FIG. **13**, when an axial clearance is produced between the bearing **45** and the engagement part **149**, an end part **55** opposite to the axial end part **153** of the driving side external gear part **52** is designed to be contacted on the bottom wall part **118**. The axial end part **153** can effectively achieve the function of the thrust receiving surface of the stoppers **23**A, **23**B, **23**C.

(11) In a case where the axial clearance is produced between the bearing **45** and the engagement part **45** as described above, the second thrust clearance between the planetary frame **40** and the planetary gear **50** can be reduced by a way that the opposing end part **55** is contacted on the bottom wall part **118**. This method may also be applied to another embodiment corresponding, for example, to the first embodiment (refer to FIG. **14**). It should be noted that, in FIG. **14**, the axial end surface **24** of the driving-side internal gear **114** achieves the function of the thrust-receiving surface of the stoppers **23**A, **23**B, **23**C. A clearance is provided between the axial end part **253** and the axial end surface **28**.

(12) In the fifth embodiment, the size relationship between the diameters of the internal gear parts **14** and **22** mutually deviating in the axial direction may be reversed from the one shown in FIG. **10**. The size relationship between the diameters of the external gear parts **52** and **54** mutually deviating in the axial direction may also be reversed from the one shown in FIG. **10**. Further, in the fifth embodiment, at least one of the external gear parts **52** and **54** and at least one of the internal gear parts **14** and **22** corresponding thereto may be respectively modified with the internal gear parts and the external gear parts.

(13) In the fifth embodiment, instead of providing the bearing **45**, the planetary gear **50** may be structured to be directly supported by the planetary frame **40** to position the supporting portion on the inner periphery side of the tooth bearing centers C**1** and C**2**. Further, in the fifth embodiment, the inner race **212** of the bearing **45** is press-fitted into the outer periphery side of the planetary frame **40**. The outer race **210** of the bearing **45** may be structured to be engaged with the inner periphery side of the planetary gear **50**, thus supporting the planetary gear **50** on the inner periphery side of the tooth bearing centers C**1** and C**2** by the bearing **45** integral with the planetary frame **40**.

(14) In the fifth embodiment, the axial end surface **200** of the driven side gear part **22** in the driven-side rotary element **20** may be structured not to contact with the axial direction end surface **53** of the driving side external gear part **52**. Furthermore, in the fifth embodiment, the driving-side rotary element **10** may be structured to contact with the axial end surface of the driving side external gear part **52**, as shown in FIGS. **13** and **14**. Further, the rotary elements **10** and **20** may be structured to contact with the axial end surface of the driven side external gear part **54** (not shown).

While only the selected example embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from the disclosure that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing description of the example embodiments according to the present invention is provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A valve timing controller for controlling a valve timing of at least one of an intake valve and an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft, comprising:

a first rotary element including a first gear part for rotating in response to one of the crankshaft and the camshaft;

a second rotary element including a second gear part neighboring to the first gear part in the axial direction for rotating in response to the other of the crankshaft and the camshaft;

a third rotary element including a third gear part and a fourth gear part, the third gear part and the fourth gear part being meshed respectively with the first gear part and the second gear part and performing a planetary motion to vary a relative rotational phase between the first rotary element and the second rotary element;

a stopper radially extending in one rotary element of the first rotary element and the second rotary element for regulating a relative rotational phase shift angle between the first rotary element and the second rotary element; and

an interposing assembler provided either at an other rotary element of the first rotary element and the second rotary element or between the other rotary element and the third rotary element for rotatably interposing the stopper of the one rotary element in the axial direction.

2. A valve timing controller according to claim **1**, wherein the stopper circularly extends inside of the interposing assembler along the relative rotational direction.

3. A valve timing controller according to claim **1**, wherein a plurality of the stoppers are arranged in the interposing assembler over the circumferential direction.

4. A valve timing controller according to claim **3**, wherein: the plurality of the stoppers are arranged at equal intervals over the entire circumference in the relative rotational direction.

5. A valve timing controller according to claim **1**, wherein the interposing assembler has a thrust groove extending in the circumferential direction along with the relative rotational direction of the stopper.

6. A valve timing controller according to claim **5**, wherein a plurality of sets of the thrust grooves and the stoppers are provided.

7. A valve timing controller according to claim **5**, wherein the interposing assembler includes a dividing rotary element which divides the other rotary element into two pieces in the axial direction; and

the thrust groove is defined by two end surfaces of the dividing rotary element opposing with each other.

8. A valve timing controller according to claim **7**, wherein a clearance adjusting member is provided between the end surfaces to be interposed between either one of the end surfaces and the stopper.

9. A valve timing controller according to claim **5**, wherein the thrust groove is open so as to extend in the circumferential direction along an inner wall of the other rotary element.

10. A valve timing controller according to claim **5**, wherein the interposing assembler is formed of the other rotary element and the third rotary element; and

the stopper is interposed in the axial direction between the third rotary element and the end surface at the opposite side of the third rotary element out of the end surfaces of the thrust groove in a state where the stopper is accommodated into the thrust groove.

11. A valve timing controller according to claim **1**, wherein the third rotary element is a planetary gear accommodated between the first rotary element and the second rotary element.

12. A valve timing controller according to claim **11**, wherein

an axial movement of the stopper is regulated by any one of an axial end surface of the gear part provided on the other rotary element, an axial end surface of either one of the third gear part and the fourth gear part of the third rotary element, and an extension part extending between the third gear part and the fourth gear part.

13. A valve timing controller for controlling a valve timing of at least one of an intake valve and an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft, comprising:

a first rotary element including a first gear part for rotating in response to one of the crankshaft and the camshaft;

a second rotary element including a second gear part neighboring to the first gear part in the axial direction for rotating in response to the other of the crankshaft and the camshaft; and

a third rotary element including a third gear part and a fourth gear part, the third gear part and the fourth gear part being meshed respectively with the first gear part and the second gear part and performing a planetary motion to vary a relative rotational phase between the first rotary element and the second rotary element;

a stopper provided so as to radially extend in one rotary element of the first rotary element and the second rotary element for regulating a relative rotational phase shift angle between the first rotary element and the second rotary element; and

an interposing assembler provided at the other rotary element of the first rotary element and the second rotary element for rotatably interposing the stopper of the one rotary element in the axial direction.

14. A valve timing controller according to claim **13**, wherein:

the interposing assembler includes a dividing rotary element which divides the other rotary element into two pieces in the axial direction and integrates them into one piece and a thrust groove defined by two end surfaces of the dividing rotary element opposing with each other; and

the thrust groove interposes the stopper in the axial direction.

15. A valve timing controller for controlling a valve timing of at least one,

of an intake valve and an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft, comprising:

a first rotary element including a first gear part for rotating in response to one of the crankshaft and the camshaft;

a second rotary element including a second gear part neighboring to the first gear part in the axial direction for rotating in response to the other of the crankshaft and the camshaft; and

a third rotary element including a third gear part and a fourth gear part, the third gear part and the fourth gear part being meshed respectively with the first gear part and the second gear part and performing a planetary motion to vary a relative rotational phase between the first rotary element and the second rotary element;

a stopper radially extending in one rotary element of the first rotary element and the second rotary element for regulating a relative rotational phase shift angle between the first rotary element and the second rotary element; and

an interposing assembler structured by the other rotary element of the first rotary element and the second rotary element and the third rotary element for rotatably interposing the stopper of the one rotary element in the axial direction.

16. A valve timing controller according to claim **15**, wherein:

the interposing assembler includes a dividing rotary element which divides the other rotary element into two pieces in the axial direction and integrates them into one piece and a thrust groove defined by two end surfaces of the dividing rotary element opposing with each other; and

the interposing assembler interposes the stopper in the axial direction between the third rotary element and the end surface of the thrust groove in a state where the stopper is accommodated in the thrust groove.

17. A valve timing controller for adjusting a valve timing of at least one of an intake valve or an exhaust valve which is opened/closed by a camshaft by torque transmitted from a crankshaft, comprising:

a first rotary element including a first gear part for rotating in synchronization with the camshaft,

a second rotary element including a second gear part for rotating in response to the crankshaft,

a planetary rotary element including a third gear part and a fourth gear part, the third gear part and the fourth gear part being meshed respectively with the first gear part and the second gear part and performing a planetary motion to vary a relative rotational phase between the first rotary element and the second rotary element; and

a planetary frame for supporting the planetary rotary element in such a manner as to perform the planetary motion at the inner periphery side of both of a first center and a second center, in a case that a tooth bearing center with the first gear part and the third gear part in the axial direction is made as a first center, and a tooth bearing center with the second gear part and the fourth gear part in the axial direction is made as a second center.

18. A valve timing controller according to claim **17**, wherein:

the planetary frame supports the planetary rotary element on a projection line in the radial direction of the first center and on a projection line in the radial direction of the second center.

19. A valve timing controller according to claim **17**, wherein:

the first rotary element or the second rotary element rotatably contacts with an end surface in the axial direction of at least one of the third gear part and the fourth gear part.

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